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COMPLAINANTS' RECORD.

VOLUME III.

EXHIBITS.

No. 835,120. PATENTED NOV. 6, 1906.

H. L. SULMAN, H. F. KIRKPATRICK-PICARD & J. BALLOT.

ORE CONCENTRATION.

949 APPLICATION FILED MAY 29, 1905.

2 SHEETS—SHEET 1

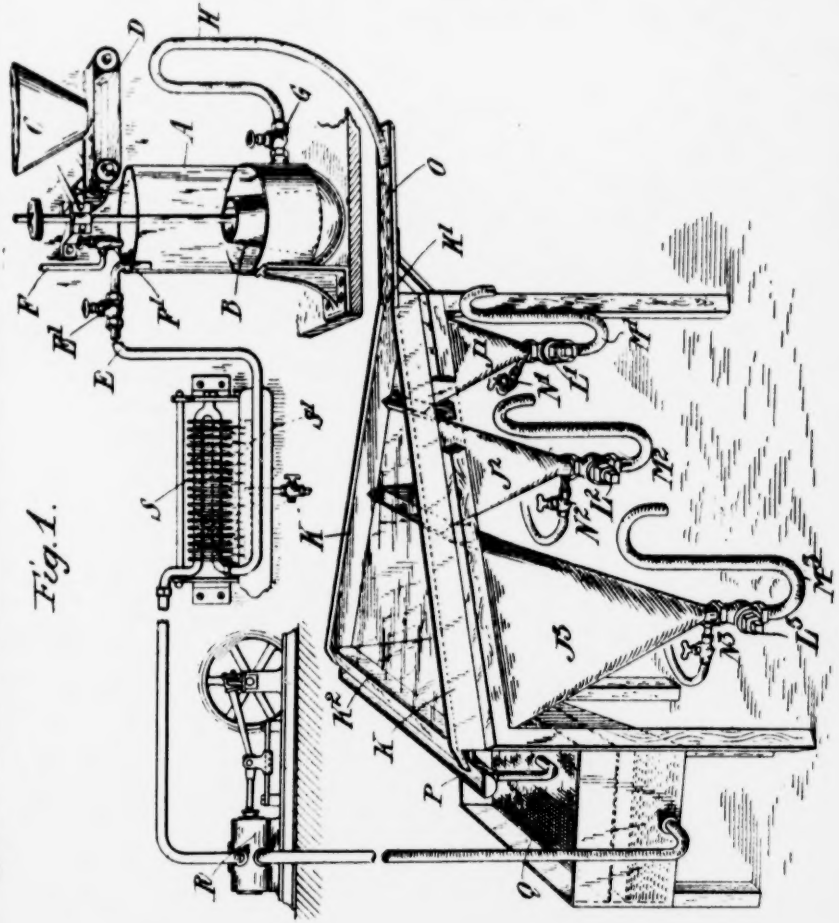

Fig. 1.

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No. 835,120. PATENTED NOV. 6, 1906.

H. L. SULMAN, H. F. KIRKPATRICK-PICARD & J. BALLOT.

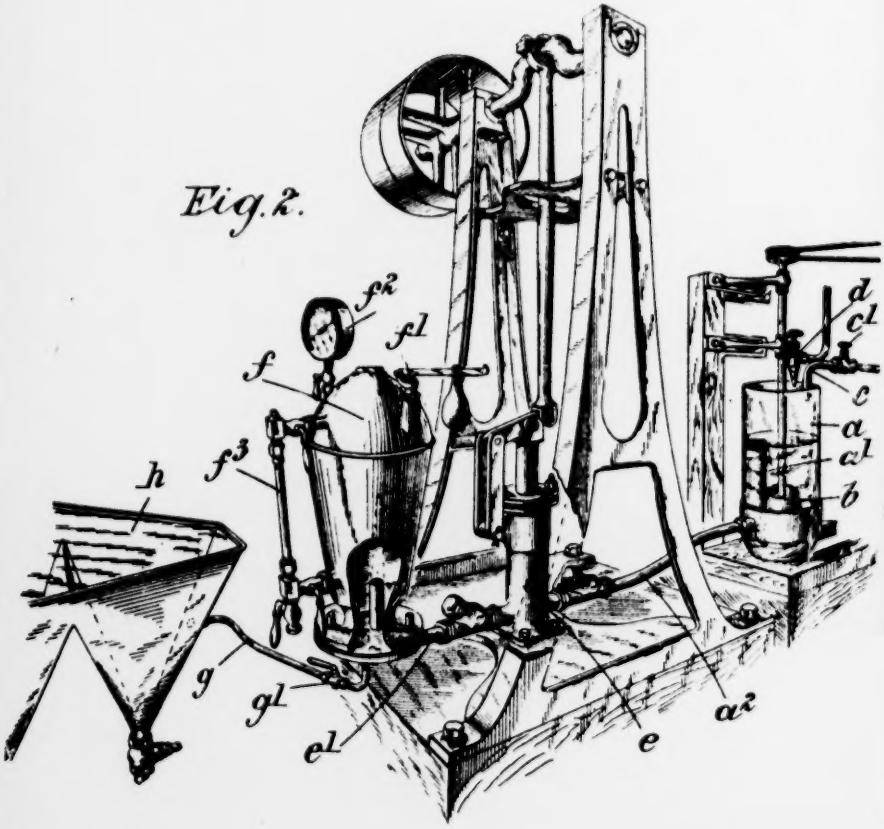
ORE CONCENTRATION.

APPLICATION FILED MAY 29, 1905

2 SHEETS—SHEET 2

1950

Fig. 2.



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UNITED STATES PATENT OFFICE.

HENRY LIVINGSTONE SULMAN, HUGH FITZALIS KIRKPATRICK-PICARD, AND JOHN BALLOT, OF LONDON, ENGLAND.

ORE CONCENTRATION.

No. 835,120. Specification of Letters Patent. Patented Nov. 6, 1906.

Application filed May 29, 1905. Serial No. 262,589.

To all whom it may concern:

Be it known that we, HENRY LIVINGSTONE SULMAN, HUGH FITZALIS KIRKPATRICK-PICARD, and JOHN BALLOT, subjects of the King of England, residing in London, England, have invented certain new and useful Improvements in Ore Concentration, of which the following is a specification.

This invention relates to improvements in the concentration of ores, the object being to separate metalliferous matter, graphite, and the like from gangue by means of oils, fatty acids, or other substances which have a preferential affinity for metalliferous matter over gangue.

In the process described in the previous United States patent, No. 777,273, granted to A. E. Cattermole, an amount of oil varying from four per cent. to six per cent. of the weight of metalliferous matter present is agitated with an ore pulp, so as to form granules which can be separated from the gangue. In the previous United States patent, No. 777,274, granted to A. E. Cattermole and others, a similar method of separation is employed, oleic acid being produced *in situ* in the ore pulp.

We have found that if the proportion of oily substance be considerably reduced—say to a fraction of one per cent. on the ore—granulation ceases to take place, and after vigorous agitation there is a tendency for a part of the oil-coated metalliferous matter to rise to the surface of the pulp in the form of a froth or scum. This tendency is dependent on a number of factors. Thus the water in which the oiling is effected is preferably slightly acidified by adding, say, a fraction of one per cent. up to one per cent. of sulfuric acid or other mineral acid or acid salt, the effect of this acidity being to prevent gangue from being coated with oily substance, or, in other words, to render the selective action of the oil more marked; but it is to be understood that the object of using acid in the pulp according to this invention is not to bring about the generation of gas for the purpose of flotation thereby, and the proportion of acid used is insufficient to cause chemical action on the metalliferous minerals present. Again, we have discovered that the tendency for the oily substance to disseminate through the pulp and the rapidity with which the metalliferous matter becomes coated is increased if the pulp is warmed. The formation of froth is assisted by the fine pulverization of the ore, and we find that slime mineral most readily generates scum and rises to the surface, while larger particles have less tendency to be included in the froth. The proportion of mineral which floats in the form of froth varies considerably with different ores and with different oily substances, and before utilizing the facts above mentioned in the concentration of any particular ore a simple preliminary test is necessary to determine which oily substance yields the proportion of froth or scum desired.

The following is an example of the application of this invention to the concentration of a particular ore. An ore containing ferruginous blende, galena, and gangue consisting of quartz, rhodonite, and garnet is finely powdered and mixed with water containing a fraction of one per cent. or up to one per cent. of a mineral acid or acid salt, conveniently sulfuric acid or mine or other waters containing ferric sulfate. To this is added a very small proportion of oleic acid, (say from 0.02 per cent to 0.5 per cent on the weight of ore.) The mixture is warmed, say, to 30° to 40° centigrade and is briskly agitated in a cone mixer or the like, as in the processes previously cited, for about two and one-half to ten minutes, until the oleic acid has been brought into efficient contact with all the mineral particles in the pulp.

When agitation is stopped, a large proportion of the mineral present rises to the surface in the form of a froth or scum which has derived its power of flotation mainly from the inclusion of air-bubbles introduced into the mass by the agitation, such bubbles or air-films adhering only to the mineral particles which are coated with oleic acid. The minimum amount of oleic acid which can be used to effect the flotation of the mineral in the form of froth may be under 0.1 per cent. of the ore; but this proportion has been found suitable and economical.

If the ore were crushed to ninety mesh to the linear inch, (half of which ore will pass through one hundred and fifty mesh sieve,) the froth may contain about seventy per cent. to eighty per cent. of the metalliferous matter

present in the ore. This froth is removed from the pulp by spitzkast, upcast, skimming draining, or otherwise. After subsidence the oil-coated metalliferous matter removed as froth is separated from any liquid which may have accompanied it and treated with a dilute solution of caustic alkali, which removes the oleic acid in the form of a solution of soap.

If desired, the oleic acid used in the first instance may be produced *in situ* in the pulp by decomposing a dilute soap solution with mineral acid, as described in the previous patent, No. 777,274, cited above. The oleic acid or other fatty acid forming the coating on the metalliferous matter which produces the froth may give rise to insoluble soaps on the surface of the metalliferous matter if soluble lime, iron, or other salts are present in small quantity during the production or on the breaking down of the froth with alkali. Such insoluble soaps are difficult to remove and are capable of adhering to air and causing flotation, much the same as the fatty acids do

The metalliferous matter which did not form part of the froth (generally the larger particles) remains in admixture with the gangue in the pulp. To recover this, the pulp is distributed in a thin layer on a shaking-table, convex buddle, or the like, whereon the mineral is exposed to a free-air surface which exposure may be increased by the application of air-blast or air-jets or the like and thereafter brought onto the edge or surface of liquid, whereby the metalliferous matter floats and is separated from the gangue, which sinks, as described in the specification of our previous United States application Serial No. 246,637, filed February 20, 1905.

The proportion of mineral recovered in the froth and that recovered by table flotation may be considerably varied; but, generally speaking, the froth will separate the slime mineral while the larger particles are recovered by the latter method.

In the accompanying drawings, Figure 1 is a diagram in perspective illustrating one form of apparatus suitable for carrying this invention into practice, and Fig. 2 represents in perspective an apparatus for carrying out a secondary step in the process.

Referring to Fig. 1, a mixing vessel A (of which there may be any number in series) is provided with a rotatable stirrer B. Crushed ore is fed from a hopper C into the vessel by a band D. A pipe E, controlled by a tap E', delivers circuit-water to the vessel, and oleic acid or other oil is introduced through the pipe F and tap F The outer cock G from the vessel A communicates through a swan-neck pipe H with the froth separating apparatus. In passing from the frothing apparatus A to the spitzkasten (say between O and K) the pulp may, if desired, be run in a thin layer over a smooth slightly-inclined plane.

The froth-separating apparatus comprises several (say three) pointed boxes J' J² J³ which open at the top into a horizontal channel consisting of side walls K. The channel has a narrow inlet K' and spreads out to a wide outlet K². The pointed boxes J' J² J³ have fullway-cocks L' L² L³ at the bottom, leading to swan-neck discharge-pipes M' M² M³. An upcurrent of water may be led in at the bottom of each box through a tap N' N² N³.

The boxes are all filled with circuit-water. The pulp from the vessel A is distributed horizontally from the flat trough O through the inlet K'. The heavy sands and coarser particles of mineral sink into the first box J', from which they are led to a shaking-table, convex buddle, or the like, to be treated as above described. The middlings or medium sands fall into the box J², and if they contain any mineral may be removed for further treatment by agitation. The upcurrent of water from the taps N' N² prevents the deposition of any slime in these boxes. The fine sands or gangue slimes settle in the last box J³, from which they are discharged to waste or further treatment.

The slime mineral in the form of froth or scum floats from the liquid and is carried by the stream over the outlet K² into a launder P and thence to a filter Q, where the metalliferous matter is removed from the circuit-water, which is returned to the vessel A by a pump R. The circuit-water may be brought to the proper temperature by passing it through a heater S, having a burner S', before admitting the water to the vessel A.

An alternative method for the recovery of any sunk-oiled metalliferous matter which may be deposited in the second and third spitzkasten is as follows: The products suspended in circuit liquor are removed from the spitzkasten and placed in a vessel in which they are submitted to an additional pressure of air or other gas of from, say, one to two atmospheres or over. On relief of such pressure the bubbles of air or other gas so generated throughout the mass at once sweep to the surface thereof all the metalliferous matter in the form of a froth which can be separated as before. This idea is not claimed broadly in this case, but forms the subject-matter of an application filed by us on January 9, 1906, Serial No. 295,326.

Referring to Fig. 2, a mixing vessel *a* (of which there may be several in series) is provided with a rotatable stirrer *b* Crushed ore or similar finely-divided mineral is fed into the vessel *a*. A pipe *c*, controlled by a tap *c'*, delivers circuit-water to the vessel, and in cases where oil is used the oil is introduced through the pipe *d* in quantity sufficient to produce a thin coating of oil on those mineral particles for which oil has an affinity.

The pulp mixed with oil escapes over the

lip of the discharge-conduit a' and passes through the pipe a^2 to a pump e. Hence the pulp is pumped through discharge-pipe e' into the closed chamber f, which is constructed to withstand a considerable internal pressure and is provided with a safety-valve f', the pressure-gage f^2, and a gage-glass f^3 to indicate the level of the pulp in the chamber. An outlet-pipe g, having a cock g', leads to a series of spitzkasten h, filled with circulating-water.

The operation is as follows: The cock g' is closed. Pulp is pumped into the chamber f, which contains air or other gas, and the pumping is continued until the pressure in the chamber rises to, say, fifty to one hundred pounds per square inch. The pressure is sufficient to cause the air or other gas to be dissolved to a considerable extent in the pulp. After the lapse of a few minutes for the due solution of the compressed air or a portion of it by the pulp or the liquid the cock g' is opened and the pulp is discharged into the open spitzkasten h, where the liquid is of course under atmospheric pressure. The pulp e may be stopped during this discharge. The whole of the mineral to which air bubbles are attached—say the oiled mineral—at once rises to the surface as a coherent scum or froth. A surface current of water is maintained in the spitzkasten, and the floating material is thus removed and separated from the gangue, which remains sunk or suspended in the liquid.

The nature and arrangement of the apparatus used may be varied without departing from this invention.

What we claim as our invention, and desire to secure by Letters Patent, is—

1. The herein-described process of concentrating ores which consists in mixing the powdered ore with water, adding a small proportion of an oily liquid having a preferential affinity for metalliferous matter, (amounting to a fraction of one per cent. on the ore), agitating the mixture until the oil-coated mineral matter forms into a froth, and separating the froth from the remainder by flotation.

2. The herein-described process of concentrating ores which consists in mixing the powdered ore with slightly-acidified water, adding a small proportion of an oily liquid having a preferential affinity for metalliferous matter (amounting to a fraction of one per cent. on the ore), agitating the mixture until the oil-coated mineral matter forms into a froth and separating the froth from the remainder by flotation.

3. The herein-described process of concentrating ores which consists in mixing the powdered ore with slightly-acidified water, adding a small proportion of an oily liquid having a preferential affinity for metalliferous matter (amounting to a fraction of one per cent. on the ore), warming the mixture, agitating the mixture until the oil-coated mineral matter forms into a froth and separating the froth from the remainder by flotation.

4. The herein-described process of concentrating ores which consists in finely powdering the ore, mixing it with slightly-acidified water, adding a small proportion of an oily substance having a preferential affinity for metalliferous matter (amounting to a fraction of one per cent. on the ore), warming the mixture, agitating the mixture until the oil-coated mineral matter forms into a froth, separating the froth from the remainder by flotation, and removing the oily coating from the mineral.

5. The herein-described process of concentrating ores which consists in mixing the powdered ore with water, adding a small proportion of oleic acid amounting to 0.02–0.5 per cent. on the ore, agitating the mixture until the oleic acid has been brought into efficient contact with the mineral and has formed a froth therewith, and separating the froth from the remainder by flotation.

6. The herein-described process of concentrating ores which consists in mixing the powdered ore with water containing a fraction of one per cent. of sulfuric acid, adding a small proportion of oleic acid amounting to 0.02–0.5 per cent. on the ore, agitating the mixture until the oleic acid has been brought into efficient contact with the mineral and has formed a froth therewith, and separating the froth from the remainder by flotation.

7. The herein-described process of concentrating ores which consists in mixing the powdered ore with water containing a fraction of one per cent. of sulfuric acid, adding a small proportion of oleic acid amounting to 0.02–0.5 per cent. on the ore, warming the mixture to 30°–40° centigrade, agitating the mixture until the oleic acid has been brought into efficient contact with the mineral and has formed a froth therewith, and separating the froth from the remainder by flotation.

8. The herein-described process of concentrating ores which consists in finely powdering the ore, mixing it with water containing a fraction of one per cent. of sulfuric acid, adding sufficient oleic-soap solution to produce oleic acid amounting to 0.02–0.5 per cent on the ore, warming the mixture to 30°–40° centigrade, agitating the mixture until the oleic acid has been brought into efficient contact with the mineral and has formed a froth therewith, separating the froth from the remainder by flotation, filtering off the froth and removing the oleic acid therefrom by treatment with an alkali.

9. The process of concentrating powdered ores which consists in separating the mineral from the gangue by coating the mineral with oil in water containing a small quantity of

oil, agitating the mixture to form a froth, and separating the froth.

10. The process of concentrating powdered ores which consists in separating the mineral from the gangue by coating the mineral with oil in water containing a small quantity of oil, warming the mixture, agitating the mixture to form a froth, and separating the froth.

11. The process of concentrating powdered ores, which consists in separating the mineral from the gangue by coating the mineral with oil in water containing a small quantity of oil, and a quantity of acid insufficient to cause chemical action on the metalliferous minerals present, agitating the mixture to form a froth, and separating the froth.

12. The process of concentrating powdered ore which consists in separating the minerals from gangue by coating the minerals with oil in water containing a fraction of one per cent. of oil on the ore, agitating the mixture to cause the oil-coated mineral to form a froth, and separating the froth from the remainder of the mixture.

13. The herein-described process of concentrating ores which consists in finely powdering the ore, mixing it with water containing less than one per cent. of sulfuric acid adding sufficient oleic-soap solution to produce oleic acid amounting to 0.02–0.5 per cent. on the ore, warming the mixture to 30°–40° centigrade, agitating the mixture until the oleic acid has been brought into efficient contact with the mineral and has formed a froth with the finer mineral, distributing the mixture on the surface of a current of water running over columns of water, so that the coarser minerals and sands, the finer sands and the gangue slimes successively deposit out while the froth is floated away by the current, filtering off the froth and removing the oleic acid therefrom by treatment with an alkali and separating the coarser mineral from the sands by exposing them alternately to air and water.

In testimony whereof we have signed our names to this specification in the presence of two subscribing witnesses.

HENRY LIVINGSTONE SULMAN.
HUGH FITZALIS KIRKPATRICK-PICARD.
JOHN BALLOT.

Witnesses:
GEO. J. B. FRANKLIN,
T. J. OSMAN.

955 COMPLAINANTS' EXHIBIT.

Assignment.

United States. No. 835,120.

Whereas, we, Henry Livingstone Sulman and Hugh Fitzalis Kirkpatrick-Picard, both of 44, London Wall, in the City of London, England, Metallurgists, and John Ballot, of 62, London Wall, in the City of London, England, Merchant, did obtain Letters Patent in the United States for "Improvement in Ore Concentration," which Letters Patent are numbered 835,120 and bear date the 6th day of November One thousand nine hundred and six.

And whereas we are now the sole owners of the said Letters Patent and all rights under the same,

And whereas Minerals Separation Limited, of 62, London Wall, in the City of London, England, is desirous of acquiring the entire interest in the same.

Now therefore to all whom it may concern, be it known that for and in consideration of the sum of One Dollar to us in hand paid, the receipt of which is hereby acknowledged, we the said Henry Livingstone Sulman, Hugh Fitzalis Kirkpatrick-Picard and John Ballot have sold, assigned and transferred and by these presents do sell, assign and transfer unto the said Minerals Separation Limited

the whole right, title and interest in and to the said "Im-
956 provements in Ore Concentration" and in and to the Letters Patent therefor aforesaid; the same to be held and enjoyed by the said Minerals Separation Limited for its own use and behoof and for the use and behoof of its legal representatives, to the full end of the term for which said Letters Patent are or may be granted, as fully and entirely as the same would have been held and enjoyed by us had this Assignment and Sale not been made.

In testimony whereof we have hereunto set our hands and affixed our Seals at London, England, this seventh day of December, 1909

HENRY LIVINGSTONE SULMAN. [L. S.]
HUGH F. K. PICARD. [L. S.]
JOHN BALLOT. [L. S.]

2 Witnesses:
HARRY SHIRLY.
H. C. HANKINS.

CITY OF LONDON, ENGLAND,
Kingdom of Great Britain and Ireland, ss:

Before me personally appeared Henry Livingstone Sulman, Hugh Fitzalis Kirkpatrick Picard and John Ballot, to me personally known

and known to me to be the individuals described in and who
957 executed the foregoing instrument, and they severally acknowledged to me that they executed the same for the uses and purposes therein set forth and that the same was their free act and deed.

Witness my hand and official seal at London, England, this Eighth day of January, A. D. 1912.

[Seal of U. S. Consulate.]

RICHARD WESTACOTT,
Vice and Deputy Consul-General of the United States of America, London, England.

(American Consular Service Fee Stamp $2.00.)

Department of the Interior.

United States Patent Office.

Received and recorded on the 28th day of August, 1911, in Liber Y, 87, page 80 of Transfers of Patents.

In testimony whereof, I have caused the seal of the Patent Office to be hereunto affixed.

[Seal of United States Patent Office.]

E. B. MOORE,
Commissioner of Patents.

958 COMPLAINANTS' EXHIBIT.

License Agreement.

(A.)

This agreement, made the tenth day of October, One thousand nine hundred and ten, between Minerals Separation Limited, having its registered Office at 62 London Wall in the City of London (hereinafter called "the Company"), of the one part, and Minerals Separation American Syndicate, Limited, having its registered Office at 62 London Wall aforesaid (hereinafter called "the Syndicate"), of the other part whereas the Company are the owners of various processes for the separation of minerals from gangue covered by patents taken out in the United States of America and in the Dominion of Canada, short particulars of which are contained in the Schedule hereto, and whereas the Syndicate has been formed for exploiting and for conducting experiments for the treatment of ores by the Company's said processes in the United States of America and Dominion of Canada, and also for acquiring and turning to

profitable account ores, tailings, dumps and also mining and other properties believed to contain minerals amenable to treatment by the Company's processes with a view to utilizing such processes in the United States of America and Dominion of Canada in connection therewith and of securing options of purchase of ores, tailings, dumps and mining and other suitable properties or substantial interests therein and otherwise giving effect to the objects of the Syndi-
959 cate as defined by its Memorandum of Association, and whereas the Syndicate has been registered in England under the Companies (Consolidation) Act of 1908 with a nominal capital of Fifty-two thousand five hundred pounds divided into Fifty thousand "A" shares of One pound each and Fifty thousand "B" shares of One shilling each, and whereas by the Syndicate's Articles of Association it is provided that the Syndicate shall enter into and carry into effect an Agreement therein referred to being these presents, now it is hereby mutually agreed between the parties as follows:

1. For the consideration hereinafter appearing the Company doth hereby give and grant unto the Syndicate (1) the sole and exclusive right license power and authority to apply use and exercise in the United States of America and in the Dominion of Canada, but not elsewhere, all or any of the inventions, processes, apparatus, plant or machinery described in the Specifications of the Letters patent of the United States of America and of the Dominion of Canada shortly described in the Schedule hereto for the term of two years from the date hereof, subject nevertheless to any compulsory licenses which may be granted pursuant to the order or direction of any Court of Law or other competent authority in either of the said countries, but so that any royalties or other considerations payable under any such compulsory licenses shall belong to and be divisible and
960 payable as follows: So much of the same as arises and is payable in respect of the said term of two years or other the period during which the License hereby granted is in force (or in the case of a lump sum consideration so much thereof as is fairly apportionable to the said term or period) shall belong and be paid to the Syndicate and the balance shall belong to the Company, provided that in the event of the said Letters patent being purchased under the option hereinafter given to the Syndicate and of the said purchase being duly completed the Company shall assign and make over to the new Company hereinafter referred to the portion of the said royalties and consideration belonging to the Company as aforesaid (2) The option or right to purchase the said American and Canadian Letters patent under and in accordance with Clause 13 hereof.

2. The Company will at any time during the said term grant to any person, firm or Company nominated by the Syndicate for the purpose and approved by the Company (such approval not to be unreasonably withheld) full license and liberty to use the said processes in the United States of America and in the Dominion of Canada, but not elsewhere in the treatment of ores obtained from properties to be specified in the said License upon such terms as may from time to time be mutually agreed between the Company and

the Syndicate, but the Syndicate shall not be entitled to
961 assign the license hereby granted or any of its benefits hereunder or to grant sub-licenses without the consent of the Company first obtained and any consideration payable to the Syndicate under any licenses to be granted under this Clause shall be carried into the account referred to in Clause 5 hereof and be reckoned in such account in ascertaining the half share of net profit payable to the Company as provided in such clause and every license shall inure for the benefit of the Company after the expiration of said term of two years or after the determination of the license hereby granted before the expiration of such term. Any royalty or other consideration payable to or receivable by the Company under any license to be granted under this Clause shall belong and be divisible and payable to the same persons and in the same manner as is provided in Clause 1 hereof with reference to royalties or other considerations payable or arising under compulsory licenses.

3. Part of the consideration for the exclusive license and the other rights and interests hereby granted to the Syndicate by the Company shall be the sum of Seven hundred and fifty pounds which shall be satisfied by the allotment forthwith to the Company or its nominees of Fifteen thousand fully paid "B" shares in the capital of the Syndicate of One shilling each.

4. As further part of the said consideration for the said License the Company shall be entitled to a further One thousand seven hundred and fifty pounds to be paid and satisfied from time to
962 time by the allotment to the Company or its nominees of one fully paid "B" share for every "A" share that may be subscribed for from time to time in addition to the Fifteen thousand "A" shares which are to be subscribed for forthwith the intention being that when the Fifty thousand "A" shares are subscribed for the Company shall be entitled to the Fifty thousand "B" shares of One shilling each fully paid.

5. As the residue of the consideration for the said License the Syndicate agree that during the said term of two years the Syndicate will use their best endeavor to apply and turn to profitable account in the United States of America and in the Dominion of Canada the processes and inventions covered by the said patents and in particular to secure and deal with in terms of the Memorandum of Association of the Syndicate options (calculated to yield profit) upon mines ores dumps tailings slimes and other suitable mining products and to secure users of the said processes on license for royalties or on profit sharing basis or otherwise and that the Syndicate will keep proper books of account and make proper and sufficient entries therein of all business and all receipts and property of the Syndicate and in particular of all matters and transactions relating and incident to the application and working of the said processes and inventions or any of them under this Agreement and the payment
963 of royalties and other considerations to the Syndicate and that all such books of account and all documents relating to the business of the Syndicate shall at all times be open to inspection and examination by the Directors of the Company and their repre-

sentatives who shall be entitled to make such copies and extracts thereof and therefrom as the said Directors and their representatives shall from time to time require and that the Syndicate will at least once during every calendar month of the said term of two years furnish and send to the Company a written report containing particulars of all mines mineral products options and properties to which any of the said processes may be applied or which may be acquired or disposed of by the Syndicate whether any of the said processes shall be applied thereto or not and the results of the Syndicate's operations with regard thereto and that the Syndicate will within thirty days after every tenth day of April and tenth day of October during the said term of two years send to the registered Office of the Company a full and detailed account of the business carried on and royalties and other considerations and moneys received by the Syndicate and outgoings and expenses incurred by the Syndicate during the half years respectively ending on the dates before mentioned and showing the net profit earned by the Syndicate for such half year and that the Syndicate will at the same time pay to the Company one half of the net profit earned by the Syndicate during each such half year as royalty and additional consideration
964 for the granting of the License hereby granted provided that the Company shall give credit to the Syndicate on receipt of the said half of the net profit for all sums receivable by the Company by way of dividend on the said "B" shares held by the Company the intention of these presents being that the Company shall receive one half of all net profits made by the Company from whatsoever source and that if the Syndicate shall duly pay the said half of the net profit the Company shall pay to the Syndicate or allow to them in account all sums receivable by the Company by way of dividend on the said "B" shares as aforesaid in respect of the period for which the said half of the net profit has been paid and further that if the Syndicate shall not purchase the said Patents under Clause 13 hereof or if this license shall be determined before the expiration of the said term of two years the Syndicate shall at the end of the said term or on the earlier determination of this license deliver to the Company all the Syndicate's books of account and all documents belonging to it in any way relating to the said processes and inventions including all deeds or agreement of license in the Syndicate's possession and that all such books and documents shall thereupon become the absolute property of the Company.

6. And it is hereby mutually agreed that in case any question or dispute shall arise between the parties hereto as to the amount of the profits from time to time earned by the Syndicate or as to any
965 matter of account between the parties hereto such question or dispute shall be determined by the Auditors for the time being of the Company whose Certificate in writing relating thereto shall be conclusive and binding upon both parties.

7. The Syndicate shall not without the written consent of the Company during the said term of two years or at any time thereafter directly or indirectly use or employ or be in any way party or privy to the using or dealing with any process or processes for the concen-

tration of ores by flotation methods of separation of products of concentration from one another belonging to or held or worked by any other Company Corporation Syndicate or person but shall exclusively use deal and be interested in the process or processes patents and inventions of the Company.

8. The Syndicate shall not at any time during the said term of two years or at any time thereafter and whether the license hereby granted shall be determined before the expiration of such two years or not dispute the validity of any of the patents or patent rights belonging to the Company nor in any manner support any litigation against the Company nor shall the new Company hereinafter mentioned at any time hereafter dispute such validity or in any manner support any such litigation as aforesaid.

9. The Syndicate hereby agrees with the Company that
966 the Syndicate and the new Company mentioned in Clause 13 hereof will so long as the term of any of the said scheduled patents or of any patent in the United States of America or the Dominion of Canada for any improvement thereon or addition thereto belonging to the Company or the Syndicate shall continue forthwith from time to time communicate to the Company and transfer to it the sole and exclusive benefit of any improvement in or addition to the said inventions or processes or any discovery mechanical or otherwise useful in connection therewith which the Syndicate or the new Company or their respective servants agents and workmen may make devise or discover during the continuance of this Agreement and will give to the Company full information as to the exact mode of working and using the same and will from time to time at the request and expense of the Company but without making any charge therefor execute and do all such documents and things as may be requisite for the purpose of enabling the Company in its own name to obtain patents or protection for such improvements or discoveries in this or any foreign Country and will from time to time during the continuance of this Agreement gratuitously give all such advice explanation and instruction to the officers and workmen of the Company as may be necessary to enable them effectually to exercise work and utilize such improvements and discoveries as aforesaid but any such patent granted to or vested in the Company in respect of the United States of America and the
967 Dominion of Canada shall be subject to the license hereby granted in the same manner in all respects as the Patents mentioned in the Schedule hereto.

10. The Company will during the continuance of this Agreement at the request and expense of the Syndicate give to the Syndicate all such technical advice and assistance as they may reasonably require in connection with all of the said processes of the Company and the methods of working the same.

11. If at any time or times hereafter during the said term of two years so long as the license hereby granted shall subsist or (in case the Syndicate shall exercise the said option to purchase) at any time during the terms of any of the said Patents the Company shall acquire or otherwise become possessed of or interested in any improve-

ment or improvements upon the inventions the subject matter of the existing Letters Patent or the mode of using or applying the said processes then and in every such case the Company shall forthwith communicate such improvement or improvements to the Syndicate and give to the Syndicate or its duly appointed officer or officers full and sufficient information instructions and assistance respecting the mode of working and using any such improvement or improvements and the Syndicate shall be entitled (so far as the Company shall be legally competent to confer such right) to use and exercise
968 the same in the United States of America and in the Dominion of Canada but not elsewhere without any further payment or compensation except actual and pocket expenses to the Company in respect thereof and if the Company shall be entitled to confer the right to do so and the Syndicate shall duly exercise its said option to purchase the said Scheduled patents the Syndicate shall be entitled to Letters Patent for the United States of America and the Dominion of Canada but not elsewhere in respect of such improvements and the Company will at the cost of the Syndicate or its assigns cause to be done all such acts and things as may be necessary for obtaining such Letters Patent as the Company shall be entitled thereto and for vesting the same in the new Company hereinafter mentioned.

12. The Syndicate shall during the said term of two years pay all necessary fees for keeping the said patents and patent rights in force and if during such term any infringement of any of the said Letters Patent shall come to the knowledge of either party hereto such party shall forthwith give notice of such infringement to the other but it shall not be obligatory on either party to take proceeding to restrain or recover damages in respect of such infringement or otherwise for defending or upholding any such patents.

13. For the considerations before mentioned the Syndicate shall be entitled at any time during the said term of two years unless the license hereby granted shall have been previously determined
969 to purchase all the said Patents of the United States of America and Dominion of Canada and the Company if the Syndicate's option shall be duly exercised will sell such patents accordingly upon the conditions following:

(*a*) The consideration for such sale shall be a sum payable in fully paid One pound shares of a New Company to be registered by the Syndicate in England to acquire the said Patents equal to one half of the total registered nominal capital of such new Company which shall be accepted in substitution for all the Company's rights in respect of "B" shares in the Syndicate of One shilling each then held by them or their nominees except the right to participate in surplus assets on any distribution in a winding up of the Syndicate.

(*b*) The total nominal capital of the said new Company shall be not less than two hundred thousand pounds and such capital shall be divided into shares of One pound each and at least one fourth of the total nominal capital of such new Company shall on or before completion of the sale be allotted to responsibe persons on subscriptions for payment in full of cash free of all deduction in respect of underwriting commission or other charges or expense of any kind.

(*c*) At least one half of the first Directors of the New
970 Company shall be nominated by the Company (party hereto) and the Memorandum and Articles of Association of the new Company shall be in such form and shall contain only such clauses as shall be approved by the Company (party hereto) and in the case of any difference or dispute arising between the parties hereto respecting the terms of such Memorandum and Articles such difference or dispute shall be determined by reference to arbitration under clause 16 hereof.

(*d*) The Syndicate shall send to the Company's registered address at least three calendar months' notice in writing of their intention to exercise the option to purchase such notice to expire on or before the end of the said term of two years.

(*e*) Upon completion of the said sale the said patents or such of them as shall then subsist and such right to improvements as the Syndicate may be entitled to under this Agreement shall be duly assigned or vested in the said new Company and the new Company shall in such Assignment enter into a covenant with the Company (party hereto) to carry out the obligations of clauses 8 and 9 hereof so far as such obligations are to be observed by the new Company.

(*f*) In case when the notice shall be given by the Syndicate under sub-clause (*d*) of this clause or thereafter prior to completion
971 of the purchase any legal proceedings shall be pending relating to the validity of any Letters Patent of the United States or the Dominion of Canada for the time being subject to this Agreement or to any alleged infringement of any such Letters Patent in which proceedings the Company shall be a party as Plaintiff Defendant Petitioner or otherwise the Syndicate shall procure the new Company on or before completion of the purchase to pay to the Company (party hereto) all costs and expenses which the last named Company may have incurred or for which it may be liable and to enter into a sufficient covenant to pay and discharge and indemnify the Company (party hereto) against all costs and expenses which may thereafter be incurred or which the Company (party hereto) may become liable to pay in or in respect of any such proceeding.

(*g*) The said sale shall be made subject to any license which may be granted under clause 2 hereof but the new Company shall after the said sale be entitled to the royalties or other consideration payable under any such license.

(*h*) Unless the said purchase shall be completed upon the conditions hereinbefore mentioned and on or before the expiration of the said term of two years the said option shall cease and all the agreements and obligations on the part of the Company under
972 this Agreement shall be at an end and for the purposes of this cause time shall be deemed to be of the essence of the Contract.

14. If the option to purchase contained in clause 13 hereof shall not be exercised or if such purchase shall not be duly completed then or if the said license should be determined before the end of the said term of two years all improvements on or additions to any of the said processes or inventions which may have been discovered or ac-

quired by the Syndicate and all letters patent which may have been granted or applied for or on behalf of the Syndicate and the full right to apply for Letters Patent in respect of such additions and improvements in all Countries where such right may subsist shall become the absolute property of the Company and the Syndicate shall execute all such assurances as may be necessary to vest the rights to such additions and patents in the Company and in any such case the Company shall have the right and option to take over from the Syndicate all or any options and or rights for working mineral products belonging to the Syndicate and the benefit of all contracts which may have — entered into by the Syndicate for such purpose and all or any mines, ores and other mineral products which may have been acquired by the Syndicate at the price paid by the Syndicate to the Vendors or Grantors thereof respectively such option to be exercised as to all or any exclusively of the other of such
973 options rights contracts mines ores and other mineral products by notice in writing to be given by the Company to the Syndicate within six calendar months after the expiration of the said term of two years or after the determination of the license hereby granted as the case may be. Provided that if at the end of the said term of two years or at the end of the further term of one year (in case the said option shall be extended under clause 17 hereof) the Syndicate shall be engaged in applying or using any of the inventions process apparatus plant or machinery described in the specifications of any of the said letters patent to or on any specific property or properties in the United States or in Canada and if the Syndicate shall not exercise the option or right to purchase the said American and Canadian letters patent under the provision in that behalf hereinbefore contained then the Company will if requested by the Syndicate so to do grant the Syndicate a license to continue such application and user of the said inventions processes apparatus plant or machinery at or on the said specific property or properties but not elsewhere so long as the said letters patent or any of them shall be kept on foot and such application and user be continued by the Syndicate and such license shall be subject in all respects to the provisions and agreements hereinbefore contained which are applicable during the term of two years from the date hereof so far as such provisions can apply to such specific property or properties except clauses 3 and 4 of this agreement and except that such
974 license shall provide in variation of the terms of clause 12 of this Agreement that during the continuance of the said license the Company and not the Syndicate shall pay all fees necessary for keeping the said patents and patent rights in force and subject as hereinafter appears but including the agreement for the payment to the Company by the Syndicate of one half the net profits of the Syndicate by way of Royalty and so that such expression "net profits" and its application to the terms of the license so to be granted shall be deemed to mean the Syndicate's entire net profits and not only the net profits attributable to such specific property or properties as aforesaid and such license shall also contain a covenant by the

Syndicate that if after all the said letters patent shall have expired or shall have ceased to be kept on foot the Syndicate shall continue the application and user of the said inventions processes apparatus plant or machinery at or upon any property to which the said license shall apply the Syndicate will continue to pay to the Company one half of its net profits as hereinbefore defined so long as such application and user shall be so continued by the Syndicate and also a covenant by the Syndicate that the Syndicate before discontinuing such user and application on or to any property included in such license will give to the Company six calendar months' previous notice of its intention to discontinue the same and that until the expiration of such six calendar months' notice the Syndicate shall remain
975 liable to pay to the Company one half of its net profits as aforesaid earned up to the end of such six calendar months whether such user and application shall or shall not have ceased prior to the expiration of such notice Provided that the Syndicate shall not after the end of the said option period of two or three years be entitled to require the Company to grant licenses under clause 2 hereof and that nothing in this clause shall affect the right of the Company after such option period to retain any consideration paid for a license granted under that clause Provided that the license to be granted with regard to the said specific property or properties shall be a non-exclusive license and shall not prejudice or affect the right of the Company to work any of the said inventions and processes themselves or to grant other licenses to use and work the same Provided also that no such license as aforesaid shall renew or extend the option to purchase under clause 13 hereof Provided also that any specific property or properties as to which any such license as aforesaid may be granted under this clause shall be deemed to be excluded from the option contained in clause 14 hereof so long as the Syndicate shall continue to apply or use the said processes and inventions or any of them to or on the said property or properties and the Company shall have the right to purchase any such property or properties under such clause within six months after the expiration of the notice of the cessor of such application or user as hereinbefore provided.

15. Provided always that if "A" shares of the Syndicate to
976 the nominal value of Fifteen thousand pounds shall not within six months from the date hereof be allotted to responsible persons on subscriptions for payment wholly in cash or if the Syndicate shall make default for the period of at least sixty days in paying to the Company the amount of any sum certified by the Company's Auditor to be due to the Company on account of the profits of the Syndicate or if an effective resolution shall be passed or a compulsory order shall be made for the winding up of the Syndicate or if the Syndicate shall commit any breach or default of any of the agreements on its part herein contained or in the case of a breach capable of being made good shall within thirty days after it has been served by the Company with notice to do so neglect or refuse to do so then the Company at any time thereafter and notwithstanding any merely implied waiver by it of its right to do

so may by serving the Syndicate or leaving at its registered office a notice in writing for this purpose forthwith revoke and cancel the license and option hereinbefore granted and thereupon the said license and option shall be determined and the Company shall be freed from all obligations and agreements on its part herein contained or arising hereunder but without prejudice to any claim which the Company might have against the Syndicate for its share under this agreement of any of the profits of the Syndicate and which in such case shall be payable by the Syndicate apportioned up to the date of the revocation of the said license.

977 16. Subject as is hereinbefore provided with respect to matters which under clause 6 hereof shall be determined by the Certificate of the Company's Auditors it is hereby agreed that if and so often as any dispute difference or question shall arise between the Company and the Syndicate as to the meaning or construction or the effect incident or consequence of this agreement or any part thereof or any article or clause herein contained or otherwise relating to the premises every such dispute difference or question shall be referred to Arbitration in England pursuant to the Arbitration Act 1889 or any statutory modification or re-enactment thereof for the time being in force.

17. In the event of the Syndicate being desirous of having an extension of the option hereby granted and of such desire shall give to the Company notice in writing not less than three months prior to the expiration by effluxion of time of the license granted by clause 1 hereof then the Company will on the Syndicate paying to the Company the further sum of Five thousand pounds in cash extend the license and option hereby given for a further period of one year and in such case this Agreement shall be read and construed as if the license granted under clause 1 hereof had originally been granted for three years instead of two.

As witness the respective Common Seals of the Companies parties hereto.

United States of America.

No.	Date of patent.	Name of applicant.	Description.	Known as—
777,273.	13, 12, '04.	A. E. Cattermole	Separation of the metallic constituents of ores from gangue	Separator.
763,259.	21, 6, '04.	A. E. Cattermole	Classification of the metallic constituents of ores	Classifier.
763,260.	21, 6, '04.	A. E. Cattermole	Separation of the metallic constituents of ores from gangue	Separator.
793,808.	4, 7, '05.	Sulman & Picard	Ore Concentration	Bubbles.
788,247.	25, 4, '05.	Cattermole, Sulman & Picard	Ore Concentration	Soap and Flotation.
777,274.	13, 12, '04.	Cattermole, Sulman & Picard	Concentration of Minerals from Ores	Soap and Granulation.
879,985.	25, 2, '08.	H. L. Sulman	Separation of Metalliferous minerals from gangue	Table Flotation.
835,120.	6, 11, '06.	Sulman, Picard & Ballot	Ore Concentration	Oleic Acid Froth.
835,143.	6, 11, '06.	H. L. Sulman	Ore Concentration	Boiling.
835,479.	6, 11, '06.	Sulman, Picard & Ballot	Ore Concentration	Superaerator.
902,018.	27, 10, '08.	H. L. & E. A. Sulman	Ore Concentration	Buddle.
955,012.	12, 4, '10.	H. L. Sulman	Concentration of Ores	Alcohol.
962,678.	26, 6, '10.	Sulman, Greenway & Higgins	Ore Concentration	Solution.
953,746.	5, 4, '10.	T. J. Hoover	Apparatus for Ore Concentration	Froth Apparatus with baffle.
Despatched.	6, 7, '10.	T. J. Hoover		Froth apparatus agitator as pump.

87,785.	14, 6, '04.	A. E. Cattermole.....	Improvements in the separation of the Metallic Constituents of ores from gangue	Separator.
87,786.	14, 6, '04.	A. E. Cattermole.....	Improvements in the classification of the metallic constituents of ores	Classifier.
87,700.	7, 6, '04.	Sulman & Picard.....	Improvements in or relating to ore concentration	Bubbles.
94,516.	1, 8, '05.	Cattermole, Sulman & Picard...	Improvements in or relating to concentration of minerals from ores	Soap.
96,183.	21, 11, '05.	Sulman, Picard & Ballot.....	Improvements in or relating to ore concentration.....	Air Flotation combined.
96,182.	21, 11, '05.	Sulman, Picard & Ballot.....	Improvements in or relating to ore concentration	Oleic Acid Froth.
94,332.	25, 7, '05.	Sutton, Steele & Steele.....	Electrical process of separating the particles of a mass of the components of a mixture of material in solid (pulverized) liquid or gaseous form.....	Di-electric Separator.
94,718.	15, 8, '05.	Sutton, Steele & Steele.....	Dry concentrating table and particularly to a construction by which a riffled table is adapted for use in dry concentration by the use of air as a floating medium for the material.....	Dry Concentrating Table.

Dominion of Canada.—*Continued.*

No.	Date of patent.	Name of applicant.	Description.	Known as—
99,743.	26, 6, '06.	Sulman, Picard & Ballot.....	Improvements in or relating to ore concentration	Superaerator.
Ser. No. 152,162.		T. J. Hoover.....		Froth apparatus with baffle.

Despatched 29, 1, '10.

[Seal of Minerals Separation, Limited.]

The Common Seal of Minerals Separation, Limited, was hereto affixed in the presence of
S. GREGORY,
W. W. WEBSTER,
Directors.
A. O. WILLIAMS, *Secretary.*

[Seal of Minerals Separation American Syndicate, Limited.]

The Common Seal of Minerals Separation American Syndicate, Limited, was hereto affixed in the presence of
JOHN BALLOT,
FRANCIS L. GIBBS,
Directors.
A. O. WILLIAMS, *Secretary.*

980 KINGDOM OF GREAT BRITAIN AND IRELAND,
City of London, England, ss:

Before me personally appeared Seth Gregory and Walter Williams Webster, to me personally known, who being by me duly and severally sworn, did each depose and say that he is and was on October 10, 1910, a director of Minerals Separation, Limited, one of the corporations described in and which executed the above instrument, and that Albert Owen Williams, is and was on October 10, 1910, the Secretary thereof, and did further each depose and say that he knew the seal of the said corporation; that the seal affixed to said instrument was such corporate seal; that it was so affixed by order of the Board of Directors of the said corporation on October 10, 1910, and that he then signed his name thereto by like order; and the said Seth Gregory and Walter Williams Webster acknowledged the said instrument to be the free act and deed of the said corporation.

Witness my hand and official seal at London, England, this Eighth day of January, A. D. 1912.

[Seal of U. S. Consulate.]

RICHARD WESTACOTT,
Vice and Deputy Consul-General of the United States of America, London, England.

(American Consular Service Fee Stamp $2.00.)

981 KINGDOM OF GREAT BRITAIN AND IRELAND,
City of London, England, ss:

Before me personally appeared John Ballot and Francis Lomax Gibbs, to me personally known, who being by me duly severally sworn, did each depose and say that he is and was on October 10, 1910, a director of Minerals Separation American Syndicate, Limited, one of the corporations described in and which executed the above instrument, and that Albert Owen Williams is and was on October 10, 1910, the Secretary thereof; and did further each depose and say that he knew the seal of the said corporation; that the seal affixed to said instrument was such corporate seal; that it was so affixed by order of the Board of Directors of the said corporation on October 10, 1910, and that he signed his name thereto by like order; and the said John Ballot and Francis Lomax Gibbs acknowledged the said instrument to be the free act and deed of the said corporation.

Witness my hand and official seal at London, England, this Eighth of January, A. D. 1912.

[Seal of U. S. Consulate.]

RICHARD WESTACOTT,
Vice and Deputy Consul-General of the United States of America, London, England.

(Consulate General American Consular Service Fee Stamp $2.00.)

982 COMPLAINANTS' EXHIBIT.

Stipulation.

United States District Court, District of Montana.

In Equity.

MINERALS SEPARATION, LIMITED, and MINERALS SEPARATION AMERICAN SYNDICATE, LIMITED, Complainants,

vs.

JAMES M. HYDE, Defendant.

It is hereby stipulated that, pursuant to Clause 17 of the agreement between Minerals Separation, Limited, and Minerals Separation American Syndicate, Limited, complainants herein (such license agreement being in evidence as "Complainants' Exhibit, License Agreement"), the license and option to Minerals Separation American Syndicate, Limited, under the patents referred to in the schedule annexed to said agreement, including the patent in suit, have been extended for a further period of one year from October 10, 1912, and that this stipulation shall have full force and effect as evidence of that fact.

New York, N. Y., Dec. 2, 1912.

HENRY D. WILLIAMS,
Counsel for Complainants.

SHERIDAN, WILKINSON, SCOTT & RICHMOND,
Counsel for Defendant.

Chicago, Ill., Nov. 29, 1912.

983 COMPLAINANTS' EXHIBIT.

Abstract of Title.

Department of the Interior.

United States Patent Office.

To all persons to whom these presents shall come, Greeting:

This is to certify that the annexed is a true copy from the Digest of this Office of all Assignments, Agreements, Licenses, Powers of Attorney, and other instruments of writing, found of record up to and including September 18, 1911, that may affect Letters Patent granted to Henry L. Sulman, Hugh F. Kirkpatrick-Picard and John Ballot, London, England. Patent No. 835,120. Dated November 6, 1906. "Ore Concentration." Searched from August 23, 1902.

In testimony whereof I have hereunto set my hand and caused the seal of the Patent Office to be affixed at the City of Washington this twenty-ninth day of September, in the year of our Lord one thousand nine hundred and eleven and of the Independence of the United States of America the one hundred and thirty-sixth.

[Patent Office Seal.]

F. H. TENNANT,
Assistant Commissioner of Patents.

HENRY L. SULMAN,
HUGH F. KIRKPATRICK-PICARD AND
JOHN BALLOT.

1.

984 Instrument Dated Dec. 7, 1909. Recorded Aug. 28, 1911.

Liber Y. 87, Page 80.

Parties:

Henry Livingstone Sulman, H. F. K. Picard, John Ballot to Minerals Separation, Limited, 62 London Wall, London, England.

Invention:

Ore Concentration.
Nov. 6, 1906, 835,120.

These Assignors, stating that they own said letters patent, and all rights thereunder, assign the whole right, title and interest in said invention and letters patent. Consideration, $1.—

COMPLAINANTS' EXHIBIT.

Chapman Report, August 16, 1907.

The Sulphide Corporation Limited.

Central Mine,

Broken Hill, N. S. W.

August 16th, 1907.

Theodore J. Hoover, Manager Minerals Separation, Ltd., London.

DEAR SIR:

Zinc Corporation, Ltd.

985 On Mr. Courtney's last visit to Broken Hill he instructed me to report briefly on the working of the Granulation Process on the British Mine.

Mr. Huntley's Regime—dating back to the time when Mr. Huntley was superintendent of the Zinc Corporation's Broken Hill Works, I was taken over the Potter Process Plant erected under Mr. Queneau's instructions and according to his ideas. Mr. Huntley was very anxious to try this plant with a little oil added to the agitation without addition to the plant. I did not give much encouragement to this proposal and finally, Mr. Huntley arranged for a nest of agitators of our box type, together with spitz box separators of our pattern. Work was then started with very encouraging results.

The plant was very weak in its feeding and crushing stages, and I constantly advised that attention to the crushing department was quite as important as to the treatment section. Some attention was being paid to this until instructions were given that the plant was to be run to test tonnages and grade of concentrates. The feed to plant was therefore rushed and was exceedingly irregular, but high grade concentrates were recovered.

The increase of tonnage determined the weak points of the plant after several weeks of annoying petty stops due to bad methods of elevation and insufficient boiler plant.

986 Operations under Mr. Mitchell's Supervision.

It was at this time that Mr. Mitchell assumed charge of operations and various changes of the staff occurred. Again I emphasised the importance of crushing with regular feed of both grainy material and slimes produced from crushing. I was told that the plant was merely an experimental one, and it was to be run only for tonnage and grade of recovered concentrates. The management were aiming at 500 tons per day and a 46% Zn.

High Tonnages.—This mad desire for tonnage irrespective of recovery became the object of foremen and shift bosses, and nothing was left undone to produce good tonnages. The breakages to plant caused delays of 8 to 12 hours per day (average), so that when plant was running it was rushed to such an extent that it was hardly worth while putting the crude tailings through the crushing section.

Treatment Without Crushing and Irregular Feed.

Besides the feed from crusher section, an incline tramway and conveyor belt delivered current British Mill Willfley and Card table tailings together with old dump slimes to the treatment section. As regards size this feed was quite amenable to treatment, but here the worst irregularities of the feed occurred. As trucks came up the inclined tram they were tipped into a hopper directly over the
987 inclined belt. This feed to plant would last a few minutes only, and while the trucks were being returned and loaded, no feed from this source was delivered to the treatment section. I estimated that the belt was delivering feed for treatment 20% of its time, and the remainder of the time no feed was going to the agitators from this source. There is no need to state how difficult it was to regulate the acid and oil feeds to ensure successful work.

This was partially remedied by the introduction of one 5 ft. agitator which delivered its agitated pulp to the mixers for treatment.

At the time when the matter of tonnages was obviously very critical (the reason not being disclosed) shift bosses on several occasions had current British Mill jig tailings (uncrushed) tipped as Card and Wilfley tailings. As this was going on unchecked I called the attention of the officials to this underhand method of getting high tonnages. They promised to have it stopped, but this abuse continued. I, therefore, reported the matter to Mr. Mitchell, who promised that it should be stopped, but on making other visits to the plant I saw that it continued, with or without the superintendent's knowledge. I would add that the tailings from the jigs at British Mill are a product of 3 m/m. crushing and assay from 12% to 14% Zn.

Slimes from Crushing.—The regular feed of slimes produced from crushing along with the grainy material was a matter that I claimed had to be seen to early. No definite line of work,
988 however, was agreed upon, but the management were getting interested in this proposition when the plant shut down.

Size of Feed.—This should have been reduced to ½ m/m. and below, whereas sizing tests made gave 33% of the total feed over ½ m/m. This oversize often reached 50% of the feed, and was composed of jig tails from the dump, and jig tails direct from British Mill, the tails from the Card and Wilfley tables that were treated being of a sufficient fineness not to require further crushing.

Results.—In spite of these adverse conditions, a very high grade zinc product was being produced and shipped, and satisfaction was expressed by those in charge.

When the 500 tons per day limit had been reached and the plant was running smoothly, I again suggested that more attention be paid to crushing to ensure higher recoveries. Mr. Mitchell then expressed the opinion that finer crushing would not give better results, and, no doubt, reported the same to his Board.

I was certain that this was the remedy of the trouble, and was glad to know that the plant was to be given over to work on our own crushing lines for a definite period.

As you know, when negotiations were being made the plant was shut down without notice.

Yours faithfully,

GEO. A. CHAPMAN.

989 COMPLAINANTS EXHIBIT.

Higgins Report, January 4, 1911.

2 King John's Court, E. C.,

4th Jan., 1911.

Messrs. Minerals Separation Limited, 62 London Wall, E. C.

DEAR SIRS:

Re "Tecolotes Slime Tails."

The tests made on this ore show that it is amenable to treatment although low in metallic values; for this reason a high recovery cannot be expected. The grade of the concentrates in zinc is good, especially in test No. 220 where no acid was used. The limit of the zinc assay in the concentrates calculated from the figures given is 44.5%. In my opinion the bulk of the insolubles in the cons. resulted from the 2nd & 3rd treatments where only small bulks were obtained, so that by eliminating these a higher grade concentrate should be obtained with a slightly lower recovery, unless the 2nd & 3rd cons. were retreated.

It is noteworthy that the grade of the concentrates obtained by the use of Turpentine (Russian) is almost as good as that from the use of oleic acid with 90 lbs. of sulphuric acid, further, that Turpentine in cold circuit (12°C) was almost useless, which may have been due to the oxidation in drying the sample before it was sent to you.

I am, dear Sirs,

Yours faithfully,

A. HOWARD HIGGINS.

6. enclos.

990 COMPLAINANTS' EXHIBIT.

Hyde Letter, February 7th, 1911.

No. 1 London Wall Buildings.

London, E. C., 7th February, 1911.

Mr. A. C. Howard, City.

DEAR SIR: Since requesting you to prepare a note for me on the subject of making working tests with the frothing equipment, I have decided not to continue with Minerals Separation, and shall not need the information asked for.

I hope you have not been to any trouble in preparing it.

I shall remain in London in consultation work with several companies for two or three months.

Thanking you for the courtesies shown me, I remain,

Sincerely yours,

JAMES M. HYDE.

COMPLAINANTS' EXHIBIT.

Froment Description.

Description et instructions pour la concentration des minerais.

A. DESCRIPTION

Le materiel se compose:

1° d'un malaxeur centrifuge

2° d'une cuve à serpentin

3° d'un crible d'épuration hydraulique avec extracteurs (si cela est necessarie)

4° d'une caisse à filtre

Complainants' Exhibit—Froment Description.

La légende qui accompagne le déssin donne déjà une idée assez complète du matériel, il en est de même du matériel d'essai.

Néammoins, nous donneront quelques reinseguements supplémentaires.

A. Le malaxeur centrifuge se compose d'un corps cylindrique en tôle forte rivée avec boulons, et dans laquelle deux agitateurs marchent en sens inverse à raison de 300 tours environ par minute.

Le minerai est versé on arrivé par la petite auge située sur le coté, et l'huile est ajoutée par un petit tube situé à coté.

(Observations). Le malaxeur d'éssai peut traiter environ 2 Kil. ½ de minerai par charge. On doit faire tourner les agitateurs au fur et à mesure que l' on verse le minerai avec l'eau et le calcaire.

Pour 2 Kil. ½ de minerai il faut environ 6 litres d'eau. Tourner pendant quelques minutes, pius évacuer le minerai en tournant toujours.

B. La cuve à serpentin peut être construite en bois. Il en faut deux par malaxeur pour alterner les charges. Pendant que l' une est en travail, l'autre se remplit. Chaque cuve doit contenir environ de 200 à 400 Kilos de minerai. Cela est affaire de pratique. La hauteur est d' environ 0m. 50 sur un diamètre de 1 m. 70 suivant la densité du minerai à traiter.

Un serpentin en plomb occupe le fond de la cuve. Ce serpentin est troué, les trous sont en dessons pour éviter qu'ils ne se bouchent pas. Le tube remontant du serpentin se divise en deux branches, l'une destinée a recevoir la portion d'acide sulfurique nécessaire; l'autre, pouvant, si cela est nécessaire, etre reliée à un générateur de vapeur. La vapeur, sous faible pression, arrive par les trous du serpentin et active les réactions.

Cela est seulement nécessaire dans les pays froids. Dans le cas où cette branche ne sert pas à la venue de la vapeur, elle peut, avec avantage, remplacer le tube à eau

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Complainants' Exhibit—Froment Description.

dont il va être parle. (Dans le matériel d'essai cette chandiére a été laissée.

Un tube à eau sans pression, mais avec robinet, doit venie déboucher, à 0 m. 45 du fond, de facon a permettre l'evacuation des sulfures qui montent à la surface. Ce tube est inutile si l' on vent écumer ces sulfures où les pousser vers l' auge d' évacuation. Il peut être remplacé par une des deux branches du serpentin.

Un rateau horizontal tourne lentement dans la cuve, il set um par un arbre vertical et une poulie; il doit faire 10 à 12 tours par minute.

C. Le crible d'epuration est constitué par un cadre en bois dur, sous lequel est fixée une plaque d'aluminium percée de trous de ½ millimètre. Ce cadre est soutenu par des montants en bois auxquels il est fixé par des attaches à ecrou de façon à obtenir l'inclinaison nécessaire.

Les montants sont fixés à une cuve en bois dont la longueur est d'environ 2 M. 50, la largeur 0 m. 75. Le crible proprement dit en occupe presque toute la surface.

Le mouvement est donné par un éxcentrique mais il est nécessaire d'observer que les secousses doivent être nombreuses avec peu d'amplitude, autrement le crible fonctionnera mal.

La caisse est percée de 3 trous pour l'évacuation des résidus et ces trous correspondent à 3 divisions de la caisse. Un tube supérieur de décharge déverse les parties légères dans la caisse à filtre.

Le déssin montre 3 extracteurs pointus pour une extraction continue. Mais, dans ce cas, il faut beaucoup d' eau. Un tube à eau, sans pression, mais avec robinet, entre vers le milieu de la caisse du crible amenant doucement l'eau necessaire pour tenir toujours le crible sous l'eau.

D. La caisse à filtre est faite en bois, elle a les dimensions que l'on vent bien lui donner; il n'y a pas, à cet égard, des mésures précises. Elle est garnies de filtres doubles en toile avec poussier de charbon Au travers de ces filtres l'eau s'écoule et les sulfures sont retenus.

Complainants' Exhibit—Froment Description.

B. INSTRUCTIONS.

L'expérience a prouvé que pour arriver à la parfaite désintégration des particules constituantes du minerai sans pour cela faire de l'impalpable, le broyage doit se faire en deus fois Le première fois, le minerai broyé doit passer à travert d'un tamis No. 15, soit dans un moulin à boules, soit dans un moulin Griffin on autre. La seconde fois il doit passer dans un tamis 120 environ et le broyage sera fait par un moulin Huttington, boccard, etc.

La production est beaucoup plus grande par voie séche que par voie humide, mais il ya a plus d'impalpables. A sa sortie du second moulin, le minerai sera donc soumis à 2 on 3 spitzkasten pour éliminer la portion de schlammes trop fins pour être traités et qu' aucune méthode n' a pu traiter jusqu' ici. Dans l'état de grosseur où il doit se trouver, le minerai arrive avec un peu d'eau dans le malaxeur centrifuge toujours en mouvement Lorsque l'on juge que la quantité de minerai est suffisante (environ 2 à 300 kilos) pour constituer une charge, on ajoute 1% environ de carbonate de chaux, 2% au maximum dans les cas difficiles, et environ 1 à 1½% de huile minérale à machine. On laisse le malaxeur agir pendant 10 minutes environ, l'essentiel est que tous les grains de sulfures soient bien touchés par 1 huile.

(Observation) Si la teneur du minerai dépasse 5% de matières métalliqus, cuivre, plomb, il faudra ajouter un peu plus d' huile En thèse générale on peut compter;

1%	huile pour	jusqu' à	5%	de métaux
1½%	"	"	10%	"
2%	"	"	15%	"

Il est rare que l'on ait à enrichir des minerais contenant plus de 15% de cuivre. Dans nos contrées. Italie, France, Espagne, un minerai à 15% de métal cuivre est considéré comme riche et traité tel quel. Pour les minerais de plomb, in enrichit jusqu' à 60% de plomb, il est rare que l'on aille au Dela.

Complainants' Exhibit—Froment Description.

En conséquence, pour un minerai plombeux d'une teneur de 20% il faudra 2% huile

2° Pour une teneur de 30%.....2½% huile
3° " " 40%.....3% "
4° " " 50%.....3½% " etc.

Il est logique de penser que le carbonate de chaux suit à peu près une même proportion puisqu' il faudra davantage de gaz pour un minerai riche que pour un minerai pauvre. La dépense est donc proportionnelle à la richesse du minerai et par conséquent proportionnelle à la teneur du concentré obtenu. Le procédé en question trouve mieux son application dans le traitement des minerais pauvres que dans ceux des minerais riches. Il serait parfait, par éxemple, pour reprendre et traiter les stériles et les ½ mixtes, résidus des laveries ordinaires, surtout lorsque ces laveries ont en à traiter des minerais difficiles. Quoiqu' il en soit, après le malaxage centrifuge, le minerai est déversé, le malaxeur étant toujours en mouvement dans la cuve à serpentin.

Pendant que le malaxaur s'éxonère de sa charge de minerais dans la cuve, l'agitateur dont celle-ci est munie est mis en mouvement à raison de 10 à 12 tours par minute, de façon à ce que le minerai ne puisse se rassembler au fond en masse trop compacte.

L'acide sulfurique est versé par le tube de plomb qui sert à cet éffet. Il est bon de diluer cet acide à 30° Baumé, par éxample. La cuve doit etre remplie d'eau jusqu' à la hauteur du déversoir. Le tube de plomb qui sert à l'introduction de l'acide dans la cuve est à 2 branches, dont l'une, munie d'un robinet, peut à volonté laisser venir, ainsi que nous l'avons deja dit, de la vapeur on de l'eau. La quantité d' acide varie avec la quantité de carbonate de chaux, elle est proportionelle a cette dernière, c'est à dire qu'il faudra environ 1% d' acide à 66° Baumé pour 1% de carbonate de chaux lequel est, on l' a vu, proportionnel comme l'huile à la quantité de sulfures. Tout aussitôt que l'acide est parvenu dans le recipient et qu' il a commence à se

1905

Complainants' Exhibit—Froment Description.

mêler avec le minerai, la réaction commence de suite et la plus grande partie des sulfures gras monte à la surface entrainée par les bulles de gaz. Ils sont écumés ou poussés dans la petite auge qui sert de deversoir au récipient.

Une petite partie retombe et se mèle à la gangue, mais, des l' instant que les particules sulfureuses de cette partie ont été bien touchées par l' huile, elles se separéront facilement dans le crible d' epuration auxquelles elles seront tantôt soumises.

Lorsque la réaction est terminée, c'est à dire lorsque il ne monte plus de bulles de gaz accompagnées de sulfures au dessus du liquide, le residu composé de la gangue et d'une faiblepartie de sulfures qui y sont restées, est amené peu à peu sur le crible d'épuration.

Ce crible doit travailler par petites secousses, environ, 200 par minutes, secousses sèches et sans amplitude L' excentrique du crible d'éssai donne difficilement de ces secousses très répetées et cela se comprend. Il faut proceder par tatonnements.

Dans la partie industrielle le mouvement de ce crible sera donné par un appareil très simple, dont croquis A sur feuille séparée.

Par suite des secousses, la matière se répand uniformément en une couche mince sur le crible; les parties sulfurées grasses montent au dessus, gagnant ainsi l'extremité du crible, tandis que la gangue passe au travers la portion lourde en tête.

L'eau qui s'écoule par le déversoir du crible passe dans une caisse à filtre retenant les parties sulfurenses qui pourraient surnager.

Dans les appareils d'éssai, cette caisse à filtre n'éxiste pas. Il est facile de recevoir l'eau d'écoulement dans un vase quelconque percée d'une ouverture basse munie d' un filtre.

Si l'operation a été bieu conduite, il ne doit plus rester

1903

Complainants' Exhibit—Translation of Froment Description and Descriptive Matter on Froment Drawings.

de parties sulfureuses dans la gangue, sauf de la pyrite de fer.

Les concentrés peuvent être soumis à la presse hydraulique on au filtre-presse et par cette opération, I'on peut récupérer une très grande partie de l 'huile.

COMPLAINANTS' EXHIBIT.

Translation of Froment Description and Descriptive Matter on Froment Drawings.

29th December, 1903.

Description and Instructions for the Concentration of Ores.

A. Description.

The machinery comprises:

1. A centrifugal mixing device.
2. A vat with coil.
3. A hydraulic purification screen, with extractors (if necessary).
4. A filter case.

The explanatory writing on the drawing already gives a fairly complete idea of the machinery, the same applies to the experimental machinery.

Nevertheless, we will give a few supplementary explanations.

A. The centrifugal mixing device is composed of a cylindrical body, made of string sheet iron rivetted with bolts, in which two stirring devices work in opposite directions, making about 300 revolutions per minute.

The ore is charged, or arrives, through a small hopper or
997 shoot arranged at the side, and oil is added through a small pipe arranged at the side.

(Remarks.) The experimental mixing device is capable of treating about 2½ kilograms of ore per charge. The stirring devices must be made to rotate as ore with water and limestone are introduced.

For 2½ kilograms of ore it is necessary to have about 6 litres of water. Set the ore to rotate in the apparatus for a few minutes then discharge the ore without stopping the apparatus:

B. The vat with coil can be made of wood. Two such vats are required for each mixing device, in order to alternate the charges. While one is working, the other is being filled. Each vat must contain about 200 to 400 kilograms of ore. This is a matter of practice. The depth is about 0.50 metre and the diameter 1.70 metre,

according to the density of the ore to be treated. A lead coil occupies the bottom of the vat. The coil in question is perforated, the holes are underneath, to avoid their getting clogged. The tube rising from the coil, is divided into two branches, one intended to receive the necessary quantity of sulphuric acid, and the other, if considered necessary, can be connected to a steam generator. Steam at low pressure arrives through the holes of the coil and assists the reactions. This is only necessary in cold countries. In case the branch in question is not used for supplying steam, it can advantageously replace the water pipe hereinafter described. (This boiler was left in the experimental machinery.)

998 A pipe containing water without pressure, provided with a valve, must merge about 0.45 metre from the bottom, so as to enable the sulphides rising to the surface to be discharged. This pipe is unnecessary if it is desired to skim these sulphides or to push them towards the discharge hopper. It can be replaced by one of the two branches of the coil.

A horizontal rake turns slowly in the vat, it is operated by a vertical spindle and pulley; it must make 10 to 12 revolutions per minute.

C. The purifying screen is constituted by a frame made of hard wood, under which is fixed an aluminum plate provided with holes of ½ millimetre. The frame in question is supported by wooden uprights to which it is secured by brackets with nuts, so as to obtain the necessary inclination.

The uprights are secured to a wooden vat, the length of which is about 2.50 metres, the width 0.75 metres. The screen proper occupies nearly the whole of its surface.

The movement of the screen is effected by means of an eccentric, but it must be pointed out that the shocks must be numerous and of small amplitude, otherwise the screen will not work well.

The case is provided with three holes for the discharge of the residues, and these holes correspond to the three compartments of the case. An upper discharge tube discharges the light substances into the filter case.

999 The drawing shows three pointed extractors for continuous extraction. But in that case, a great deal of water is required. A water pipe, without pressure, provided with a valve, merges into the case about its center and slowly supplies the water required to keep the screen submerged the whole time.

D. The filter case is made of wood, it may be made of any desired dimensions—no definite measurements need be complied with in that respect. It is provided with double filters of canvas with charcoal powder in between. Water can pass through these filters, while the sulphides are kept back.

B. Instructions.

Practical experience has shown that, in order to arrive at a perfect disintegration of the constituent particles of an ore, without rendering it impalpable, it is necessary to do the crushing in two operations.

The first time the crushed ore must pass through a sieve No. 15, either in a ball crusher mill or in a Griffin Mill or any other. The second time, it must pass through a sieve of about 120 and the crushing would be effected in a Huntington Mill, stamp mill, etc.

The output is much greater by dry process than by wet process, but there is a greater proportion of impalpable particles. On leaving the second crushing mill, the ore will therefore be submitted to two or three "Spitzkasten" for eliminating the slime which is too fine to be treated and which could not be treated by any hitherto
1060 known method. Reduced to the size which it ought to have, the ore arrives with a little water into the centrifugal mixing apparatus which is always working. When it is thought the quantity of the ore is sufficient (about 200 to 300 kilograms) to constitute a Charge, about 1% of carbonate of lime, maximum 2% in difficult cases, and about 1% to 1½% of mineral engine oil are added. The mixing apparatus is left to work for about 10 minutes, the chief point is that all the sulphide grains should come into thorough contact with the oil.

(Remark.)—If the ore contains more than five per cent. of metallic matter such as copper, lead, it will be necessary to add a little more oil. As a general rule, one may assume;

1%	of oil for ore containing up to				5%	of metals.
1½%	"	"	"	"	10%	"
2%	"	"	"	"	15%	"

It is very rare that one has to enrich ore containing more than 15% copper. In our countries, Italy, France, Spain, ore containing 15% of metallic copper, is considered very rich and is treated as such. In case of lead ore, concentration is continued until the ore contains 60% of lead, this later proportion is seldom exceeded.

Consequently for a lead ore containing 20% of metallic matter, it will be neces ary to use 2% of oil.

2.	For ore containing		30%	of metallic lead		2½%	of oil.
3.	"	"	40%	"	"	3%	"
4.	"	"	50%	"	"	3½%	"

1061 It seems reasonable to assume that the proportion of the carbonate of lime follows practically the same rule, for a richer ore will require more gas than a poorer one.

The expenditure is, therefore, in proportion to the richness of the ore, and, consequently, in proportion to the metallic matter contained in the concentrated ore obtained. The process in question is more suitable for the treatment of poor ore, than for that of rich ore. It would be perfect, for instance, for taking up and treating sterile ore and ½ mixed ore, residues obtained from the ordinary washing apparatus more particularly when the washing apparatus in question had to treat difficult ore. However this may be, after the centrifugal mixing, the ore is discharged into the vat with coil, the mixing device being always in motion in the vat with coil.

Whilst the mixing device is being emptied of its charges of ore

into the vat, the stirring device, with which the latter is provided, is started at the rate of 10 to 12 revolutions per minute, so as to prevent the ore from collecting at the bottom in too compact a mass. Sulphuric acid is introduced through the lead pipe which serves for this purpose. It is advisable to use for the purpose sulphuric acid diluted to say 30° Baume. The vat must be filled with water up to the level of the overflow. The lead pipe which is used for introducing the acid into the vat, has two branches, one of which, provided with a valve, can be used to admit, whenever it may be
1002 necessary, steam or water, as already stated. The quantity of the acid varies with the quantity of the carbonate of lime, it is in proportion to the latter that is to say, it will be necessary to use about 1% of acid at 66° Baume for 1% of carbonate of lime, which, as already stated, is, like the oil, in proportion to the quantity of the sulphides. As soon as the acid has reached the vessel and begun to mix with the ore, the reaction will at once begin, and the greatest part of the greased sulphides will rise to the surface, carried by the gas bubbles. They are skimmed or pushed into a small hopper which forms an overflow for the vat.

A small proportion falls back and gets mixed with the gangue, but the moment the sulphurous particles of that part come into thorough contact with the oil, it will be easy to separate them in the purifying screen in which they would be subsequently treated.

When the reaction has been completed, that is to say when no more gas bubbles, accompanied by sulphides rise to the surface of the liquid, the residue consisting of the gangue and of a small proportion of sulphides that have remained in it, is gradually brought to the purifying screen.

This screen must work by small shocks, about 200 per minute, these shocks must be "dry," that is to say sudden, and without amplitude. It has been found difficult to produce such repeated shocks by means of the eccentric of the experimental screen, which can be easily explained. It is necessary to proceed by groping.
1003 When using it on a large scale, the screen will be caused to shake by a very simple apparatus, a sketch A, of which is given on a separate sheet. Owing to the shocks, the material spreads uniformly on the screen in a thin layer. The greased sulphurous parts rise upwards, thus arriving at the extremity of the screen, while the gangue passes through the heavy portion at the head.

Water escaping through the overflow of the screen, passes into a filter-case retaining any sulphurous particles that might come to the surface. In the experimental apparatus, this filter case does not exist. It is easy to collect the escaping water into any vessel provided with a hole at a low level, provided with a filter. If the operation has been properly carried out, no sulphurous parts should remain in the gangue, except iron pyrites.

The concentrated ore may be subjected to treatment by a hydraulic press or filter press, and by that operation a very large proportion of the oil used can be recovered.

Sketch A.

1. Iron Vibrator.
2. Spindle.
3. Spring.
4. Eccentric.
5. Iron bracket to be fixed to the vat.
1004 6. Counter-shock mounted on the vat.
7. Partitions.
8. Overflow.
9. Flexible iron stop.
10. Screen.

Large Drawing.

A. Centrifugal Mixing Device.

1. Pulley.
2. Driving shaft, 60 revs. minute.
3. Large gear.
4. 4′. Gears driving the stirrers 300 revs/min.
5. Hopper for charging in ore coming from the crusher.
6. Safety (overflow) pipe discharging into any vessel.
7. 7′. Vessels receiving the ore after the centrifugal mixing.
8. 8′ 8^2. Iron frame supporting the mixer.
9. 9′. Water pipes with valves for expelling the ore from the vessels, 7 and 7′ and introducing it into the coil vat.

B. Coil Vat.

1. Vat proper made of wood.
2. Table supporting the vat.
3. Overflow discharging sulphides into the filter case.
4. Pulley and shaft driving the rake in the interior.
1005 5. Discharge tube for the residue.
6. Drain pipe for the coil.
7. 7′. Two-branch tube of the coil.

C. Purifying Screen.

1. Screen case.
2. Water pipe with valve used, when necessary, for maintaining the case always full of water.
3. Pulley and shaft driving the screen.
4. 4′ 4^2. Supports of the screen.
5. Aluminum screen, wood mounted.
6. 6′ 6″ Discharge pipes for the residue.
7. Discharge pipe for the light sulphides falling into the filter case.
8. 8.′ 8.″ Residue in extractor, for the case that it is desired to classify it.

D. Filter Case.

1. The case proper.
2. 2.′ 2.″ 2.‴ Canvas filters consisting of a wooden frame with canvas stretched on both sides.
Between the two canvasses is contained charcoal powder.
4. Emergency discharge pipe.

1006 COMPLAINANTS' EXHIBIT.

Fryer Hill Publication.

(The Daily Herald Democrat, Leadville, October 30, 1889.)

An Important Invention.

Experiments with the Oil Rotary Concentrator.

One of the Most Novel Methods of Treating Dry Silicious Ores Ever Brought to Notice—An Exhaustive Review of the New Process—Its Advantages Particularly Applied to the Miners of Fryer Hill—News from the Mines—Shipments from the New Quartzite Strike—Mikado's New Developments.

Experiments are now being made in Denver with a new appliance for the concentration of dry silicious ores, such as those of the Dunkin, Matchless, Little Silver, and, in fact, all the mines of Fryer Hill. So far, the experiments have proved a perfect success, the tailings from the concentrator, if so it may be called—only running one ounce to silver from a crude ore that ran over ten ounces of silver per ton. The first unimportant means of testing the new system having proven so incontestably the correctness of the theory, other larger and more capable means have been employed. The whole system of concentration appears to be based on the well known affinity of the lighter forms of sulphuret and chloride of silver for oils. Petroleum is the oil now being used by the parties having these experiments in charge, and appears from its density, to possess the requisite ad-
1007 hesiveness to effect the result desired. The ore is first crushed and rolled to such a degree of fineness as to enable it to pass through a 40 mesh screen, and while dry, is thoroughly mixed with the oil, after which it is placed in a circular tank or receiver, through the center of which runs a rotating hollow tube, to the bottom of which tube is attached, on two opposite sides, a couple of fans, the lower edges of which are unevenly cut in order to send—in the revolution—the lighter particles of the ore and oil mixture to the outer sides of the drum or cylinder. This rotating hollow tube is perforated at, or near, the bottom, and, when the receiver is thoroughly charged, acidulated (sulphuric acid is used). Steam is introduced through the tube and is forced to the bottom of the mixture, while

the arasta-like fans, attached to the bottom of the tube, keep the whole mixture in motion, and the action of the revolving tube, the fans, and injected acidulated steam causes the lighter portions of the mineral-charged oil to float to a point just above the center of the receiver, where there are suspended two semi-circular doors, which, when the oil has passed above them, laden with its precious freight, are raised, and the superfluous water allowed to drain through slight perforations in the bottoms of these semi-circular doors, after which the mineral laden oil is carefully removed to settling barrels revolving with jets of steam injected continuously from the lower ends.

1008 These settling barrels being placed at an angle, permit the mineral laden oil to pass through openings in the ends, which are connected with shallow settling tubs or tanks from which the concentrated ore is shipped directly to the smelters, who will hardly be likely to refuse so pleasant an addition to their heating powers. As said above, with the present plant, which is daily being improved upon, a good, high grade concentrate is being made on ores on which no previous methods of saving the silver value has proven entirely satisfactory, and the few mining men of Fryer Hill to whom this scheme has been whispered are watching the experiment with a great deal of interest, as there are thousands of tons of such ore now awaiting treatment.

1009 COMPLAINANTS' EXHIBIT.

Criley & Everson Publication.

Nov. 15, 1890—581.

The Engineering and Mining Journal.

Oregon, Baker County.

Baker City, Nov. 10.

Quite a number of capitalists from Portland and Walla Walla are here watching the result of some test working of the "Criley & Everson Oil Process" for the extraction of sulphurets from any ore as the name signifies by the use of oil. Your correspondent witnessed a test made on the Eureka and Excelsior ore, which was conducted as follows: The ore was crushed and passed through a 50 mesh sieve, weighed and thoroughly mixed with black thick oil. To water heated to near boiling was added enough sulphuric acid to give it a tartish taste. This acidulated water was then mixed with the mass of oil and ore. A thick scum of sulphurets rose to the surface and was skimmed off, leaving the hitherto black ore as white as snow—in fact, pure silica. The gentlemen expressed themselves as pleased and the citizens of Baker County are in hopes they are, because it means the erection of a large plant at this point.

1010 COMPLAINANTS' EXHIBIT.

Statement of Profit Lazard Ventures.

Statement of Profits Made by Ventures a/c by Treatment of Material in Minerals Separation Ld. Tailings Plant with Agitation-Froth Process.

	Total.	Lazard Bros.	M. S. Ld.	S. C. Ld.
Original Joint Venture	£130,341- 8-10	£65,170-14- 5	£65,170-14- 5	
Triple Venture	51,024-11-11	12,756- 3- 0	12,756- 2-11	£25,512- 6- 0
South Blocks Venture	321- 5- 0	160-12- 6	160-12- 6	
Total	£181,687- 5- 9	£78,087- 9-11	£78,087- 9-10	£25,512- 6- 0

H. C. H.

3/9/12.

Table of Material and Results Lazard Ventures.

Table of Material Treated and Results Obtained in Minerals Separation Tailings Plant with Agitation-Froth Process.

Original Joint Venture:		Feed concentrates.		
Period.	Material.	Tonnage.	Produced tons.	Realized value.
November, 1907, to September, 1910.	Dump Tailings.....	481,859	170,290	£506,417
Triple Venture:				
September, 1910, to April, 1911.	Dump Tailings.....	50,000	14,073	
	Magnetic Tailings.....	65,682	17,316	93,419
Joint Venture (South Blocks):				
April, 1911, to June, 1911.	Middlings.....	39,258	14,502	35,535
	Total.....	636,799	216,181	£635,371
Costs:				
Paid for Tailings, per ton.....		Tails 5.04	£160,553	
Total Cost of Plant Management, Treatment, Interest, Realization, etc. (everything included).....		do. 9.20	£293,130	£453,683
Net profit.....		do. 5.71		£181,688

8/8/12. H. C. H.

1012 COMPLAINANTS' EXHIBIT.

Statement of Expenditures in Agitation-Froth Process.

Statement of Expenditure Incurred by Minerals Separation, Ld., in Introducing the Agitation-Froth Process to 31 Dec., 1911.

Plant and Laboratory Apparatus		£9,317- 1- 2
Experimental & General Expenditure:		
Management, Traveling Staff, Examination of Properties at home and abroad		62,115-16- 5
London Administration:		
Office Salaries & Rent	£5,569-17-11	
Legal Charges	1,027- 7-	
Audit Fees	177-19- 6	
General Expenses	3,428- 6- 5	
Postages and Cables	2,193-13- 9	
Interest	320-11- 9	
Directors' Fees	7,378-14- 8	
		20,096-11-
		£91,529- 8- 7

H. C. H.

4/8/12.

NOTE.—The expenditure incurred in Purchases of Patents, Patent Fees & Expenses & Patent Litigation and amounting in all to £56,-481-0-10 is not included in the above statement.

1013 COMPLAINANTS' EXHIBIT.

Statement of Expenditures by American Syndicate in Agitation-Froth Process.

Statement of Expenditure by Minerals Separation American Syndicate, Ld., in the Introduction of the Agitation-Froth Process to 31 July, 1912.

(1) Into United States of America	£12,360–15–5	
(2) Into Mexico	1,401–16–8	
(3) Into Canada	1,433– 9–7	
		£15,196–1–8

H. C. H.

2/9/12.

The above statement does not include any litigation expenses, or any of the Costs in the present suit.

1014 COMPLAINANTS' EXHIBIT.

Statement of Tonnage Treated by Agitation-Froth Process at Broken Hill, Australia.

Tonnage of Tailing & Slimes Treated by Minerals Separation Agitation-Froth Process at Broken Hill, Australia, With Concentrates Produced as per Official Returns Made by Licensees.

	Tailings & slimes—tons.	Zinc, lead, silver concentrates—tons.
Sulphide Corporation, Ld.	1,176,934	445,299
Part year ending 30" June, 1906, 30 June, 1912.		
Minerals Separation, Ld.	636,799	216,181
Jointly with Lazard Bros. & Co. & Sulphide Corporation, Ld. November, 1907, to June, 1911.		
Zinc Corporation Ld.	380,020	132,675
Nov., 1910, to 30 June, 1912.		
Broken Hill Junction North	44,261	10,449
Nov., 1911, to 12 March, 1912.		
	2,238,014	804,604
Zinc Corporation Ld..... April, 1907, to Oct., 1910.	No Returns of tonnage made but they paid £1500 in Royalties equivalent to 12,000 tons of Concentrates.	

H. C. H.

4/9/12.

1015 COMPLAINANTS' EXHIBIT.

Statement of Profits and Royalties on Agitation-Froth Process.

Minerals Separation Ld. Proportion of Profits from Joint Ventures and Royalties Received from Licensees.

Original Joint Venture:		
Total Profit	£130,341– 8–10	
Minerals Separation Ld. proportion ½		£65,170–14– 5
Triple Venture:		
Total Profit	51,024–11–11	
Minerals Separation Ld. proportion ¼		12,756– 2–11
South Blocks Venture:		
Total Profit	321– 5	
Minerals Separation Ld. proportion ½		160–12– 6
Total M. S. Ld. Profit		£78,087– 9–10
Royalties received from Licensees as far as accounted for and received in London to 30 June, 1912		£75,166– 0– 6
Royalties due but not yet paid or received in London at 30 June, 1912, are excluded		£153,253–10– 4

1016 COMPLAINANTS' EXHIBIT.

Table of Sulphide Corporation Operations With Agitation-Froth Process.

Tonnage Treated	1,176,934 tons
Concentrates Produced	445,299 tons
Total Value	£1,154,353
Per ton Feed Shillings 19.6/–	
Less Total Cost of treatment 8.5/–	£504,200
Profit, 11.1/–	£650,153

COMPLAINANTS' EXHIBIT.

Sulman & Picard Report, March 25, 1903.

Sulman & Picard.

44 London Wall, E. C.

25th March, 1903.

John Ballot, Esq., Salisbury House, E. C.

DEAR SIR: As you are aware we have carried out numerous experiments on the Cattermole process during the past 2 months, the work done being mainly of a preliminary experimental character with a view towards getting a knowledge of some of the chief factors involved.

Whilst we were feeling our way much of the work done
1017 was not of a quantitative nature and therefore no detailed records were necessary. Of late however work done has been strictly quantitative and a schedule of results is appended hereto. It will be perhaps the most convenient way if we here state the general results arrived at from the whole series of qualitative and quantitative tests without considering each test separately. Firstly, we have endeavored to reduce agitation, i. e. flocculating, breaking down, and rolling or agglomerating actions, to a mechanical standpoint and therefore have used the Gabbett cone and a mechanically rotated cylinder for all the later agitations required.

We early got away from the alkaline soap method of breaking down the first product resulting from the treatment of an ore with soap and oil emulsion by means of which the whole of the ore is precipitated from the milling waters as one uniform flocculent precipitate. This flocculating operation remains much the same as schemed by Cattermole originally. The next portion of his invention was to "break down" the flocculent precipitate into clean gangue and fine particles of oiled mineral by more or less violently agitating the flocculent precipitate with weak soap and alkali. By rolling or agglomerating the product so obtained the oily particles of mineral are made to cohere into gradually increasing shot-like granules, when they become sufficiently dense to be separable from the coarse clean sands or gangue by the action of an upward current of water.

1018 The combined minerals in the form of clean granules may then undergo further separation into their constituent minerals by the application of solutions of increasing strength in alkali.

Our work up to the present has been confined entirely to Broken Hill sulphide ores. This is a type of mineral which gives the greatest difficulty in the separation of gangue from mineral; the gangue is exceedingly heavy consisting as it mainly does of garnet and rhodonite—its specific gravity being nearly twice that of quartz, and varying from 4.3 to 4.7; and thus very nearly approaching in density that of the blende contained in the mineral. There being no diffi-

culty in the separation of blende from galena when once the separation of the two from the gangue has been effected, we have confined our investigation so far entirely to separating the gangue from the combined mineral.

So far the process described is covered by the provisional specification which Cattermole has already filed, but it was found difficult to separate such heavy gangue as exists in the Broken Hill ore from mineral by the alkaline soap "breaking down" method. It was found however that the treatment of the first flocculent precipitate by very dilute acid gives an easy and complete result and therefore the acid breaking down process has been exclusively used by us in all our late work. This is a most important development of the Cattermole process and will have to be protected by further specifications. Most of the earlier experiments, in fact all but the last one given in
1019 the schedule of results (No. 6) were made upon Broken Hill ore ground to varying meshes from 90 mesh to 120 upon a Bucking table. The results on these were very satisfactory allowing for the imperfect form of upcast apparatus used for separating the mineral granules in the last operation. The last experiment however was made upon ore ground by Messrs. Johnson & Sons of Finsbury, 5 cwt. of Broken Hill being ground, 3 cwt. to 60 mesh and 2 cwt. to 120 mesh. Mr. Cattermole and ourselves found much greater trouble in treating this material than in dealing with laboratory crushed ore. The 120 mesh material was found to be nearly all fine slimes, containing a very large proportion of free zinc blende in a state of high division, whilst the 60 mesh stuff was far more granular and contained very little slimes and much coarse sands. After many experiments however the difficulty in dealing with these products has been largely overcome and the last experiment on the schedule shows the result on 800 grammes of 60 mesh ore conducted in 3 separate lots.

Kerosene emulsion of 75% strength was used in the earliest experiments, and though this oil works well, and in the rolling operation (after breaking down) yields hard, shot-like granules, it has the disadvantage of not taking up all the blende, leaving the sands and slimes somewhat dirty with unrecovered zinc sulphide. It has been found that the substitution of thick residuum oil for the larger portion of kerosene used in the emulsion gives quite clean
1020 sands and retains every portion of the blende; but thick oil seems to leave the granules somewhat more readily affected by air, giving rise to floating granules whenever a pulp in which they are contained is exposed to the air. Pure kerosene granules also do this to some extent and we are not yet sure whether this may not be due to the acid breakdown as compared with the original alkaline method; if so, it is a difficulty which has to be overcome, as there can be no doubt that the acid breakdown is five or six times as cheap as the original alkaline soap method. The obvious remedy is to keep the granules and sands after the rolling or agglomerating stage carefully covered by water during their transference into and below the surface of the water in the upcast separating apparatus, for which purpose an open launder should not be used; but possibly

some form of submerged archimedean screw feed might be used on a large scale.

Facts which have been established so far are broadly as follows: Sharp ore alone does not give such good results as a mixture of sharp ore with slimes, as the fine mineral particles in the latter exercise a potent effect in building up the hard, shot-like granules desired, by supplying "filling material," without which the large oiled mineral particles could not become sufficiently coherent or dense. Again slimes containing mainly, or only, blendes, are not so suitable as those which contain their due proportion of fine galena, also, as blende is the mineral most difficult to take up by oil, and the
1021 first to be rejected in subsequent separations. It does, therefore, not form such good filling or cementing material for granules as does galena; but with a fair proportion of the latter ("fines") there is no difficulty in getting the blende to do its proper share of cementing work in forming the granules. These factors are those which mainly have to be considered in the original grinding of the raw ore. It becomes therefore obvious that when the mineral is ground to 60 or 70 mesh that all slimes produced should be kept strictly associated with the coarser particles and that the slimes so produced should not consist exclusively of the more readily slimed blende, but a fair proportion of galena slimes should also be present. Given these conditions, the operation of the Cattermole process has become much simplified compared with the scheme originally put forward. It is sufficient to take the ore suspended in about three to four times its weight of water and to mix this to a uniform pulp in a suitable mixer, preferably of the Gabbett type; to this suspension, while still in a state of agitation, the oil emulsion is added. The proportions requisite may vary somewhat and are shown in the schedule. Roughly speaking, we have found that the oil addition equal to about 7% upon the mineral present in the ore is sufficient. A small amount of soap solution is also necessary to obtain good flocculation and it appears to aid in the uniform dissemination of the added oil emulsion through the pulp in the mixer. A very short period of agitation is necessary to effect complete flocculation
1022 of the whole of the mineral, which readily subsides, leaving clear water above, opalescent with the soap added. The tendency of our work has been to show that a very small amount of soap is necessary and we have continually cut this down, almost to the vanishing point; still a small amount of soap during flocculation appears to be advisable. The clear solution still containing this small amount of soap is run off from the flocculent precipitate and can be used perfectly well on the next lot of mineral to be flocculated. The whole of the oil added as emulsion appears to be taken up by the ore, and none to remain in the opalescent but otherwise clear liquor. The flocculating precipitate is so open that it drains most readily from any remaining liquor which cannot be decanted. The flocculent precipitate may even receive a plain water wash with advantage. The mass is then put into about three to four times its own volume of very dilute sulphuric acid, which may vary be-

tween the limits of 0.05% to 0.1%. Somewhat violent agitation is now required for a period of a few minutes; the time being dependent upon the efficiency of the agitation, and varying from 2 to 5 or 8 minutes, whereby the oil is released from the gangue and attaches itself exclusively to the mineral. The mass changes in color and becomes much lighter owing to the liberation of the pinkish-white gangue, but the mineral remains disseminated through this mass in extremely fine granules, which require to be agglomerated by rolling treatment. It is, however, found advisable before such roll-
1023 ing treatment is given to pour off or decant at least half of the liquor resulting from the breaking down, and, with this, to include as much of the fine but now clean gangue slimes as possible, as the presence of very fine gangue slimes seems to interfere somewhat with the attaining of hard mineral granules. The pulp, which now consists of very fine oiled mineral particles dispersed through clean gangue from which the finest slime gangue has been separated, is placed in a cylinder and rotated about its horizontal axis at the rate of about 60 to 80 revolutions per minute (for a 4″ diameter cylinder) for about ten minutes. This gentle rolling action has the effect of making the mineral particles cohere and build up into the shot-like granules required. When these are found to be of sufficient size the rolling operation is stopped and the mass separated in any convenient or efficient upcast water separator. We have naturally not been able to try the experiments on a sufficiently large scale to give definite factors as to the amount of rolling travel requisite for the agglomerating in large scale plant. In a 4″ cylinder about 1,200 ft. of such rolling travel is necessary, but, with increasing quantities the "mass factor" we find constantly tends to reduce the amount of rolling travel, and it will probably be much less than the amount mentioned when larger apparatus is employed. We are constructing a cylinder of 8″ in diameter and 2′ in length fitted on the interior with slotted partitions and with a continuous inflow and discharge which will enable us to get at such a figure far more exactly.
1024 Finally, it is not always possible in the upcast apparatus used by us on the laboratory scale to effect in one operation a sharp separation into absolute gangue on the one side and clean granules free from gangue on the other. Whilst the heaviest granules come away quite clean, and the lighter sands are easily eliminated, a middle portion is apt to be formed consisting of lighter mineral granules mixed with the heavier sands; and any attempt to treat this middle portion is apt to drive over some of the smaller mineral granules with the heavy sands. We thus find it best in tests with our present small laboratory apparatus (with which it is very difficult to obtain uniform conditions and therefore uniform sized granules) to pass our rolled product through the upcast apparatus at first with only a comparatively light up-current of water. This rejects the bulk of the gangue as light sands, but gives a product containing all the granules mixed with some heavy sands. If this second product be then given a short further rolling treatment the fine granules become much larger and agglomerated with the heavier

granules, and this product is then capable of a ready separation from the remaining heavy sands in a sharp up-current of water.

It is obvious that many variations of such separation treatment are possible, and that with a little experience a very simple and efficient form of apparatus could be devised. Combinations of such apparatus could be placed in series to deal with the various
1025 sand and granule products without the necessity for a second rolling agglomeration, but up to the present the facilities at our disposal, and the small scale upon which alone it is possible to work in the laboratory, have prevented us from using any but the simplest plant. The chain of operations is therefore extremely simple.

Firstly. Suitable crushing of the ore as specified.

Secondly. Flocculating the pulps with a small amount of soap and oil emulsion in the proportions given using a fair proportion of thick oil to kerosene. (It is only necessary here to note that emulsions containing thick oil are rather more difficult to get completely "smooth" that is, free from unemulsified oil globules, than with kerosene alone; but with a little care and experience a perfect emulsion of thick oil is obtainable).

Thirdly. Breaking down the flocculent precipitate by strong agitation with very dilute acid.

Fourthly. Gentle rolling to agglomerate the fine mineral particles into shot like granules.

Fifthly. The separation of granules from gangue in a water up-current.

We are, dear Sirs,

Yours truly,

SULMAN & PICARD.

1026 *Addendum to Report.*

We omitted to state that in our last experiment, No. 6, a further simplification has been made which seems to promise well. The flocculating stage has been abandoned and .05 to .1% acid has been used direct for suspending the duly crushed ore in. The addition of "thick oil plus paraffine" emulsion has been made direct to this, and after a sufficient agitation period has been given to the mixture, the gangue is found to be free and clean whilst the mineral is disseminated through this in a state of very finely divided granulation. On pouring off the bulk of the acid liquor, together with any fine clean slimes which it may contain, and rolling the remainder as usual, excellent granulation has been found to occur. We are not yet sure how this treatment may act with finely ground mineral slimes containing much blende, but experiments are in course to determine this.

S. & P.

1027 COMPLAINANTS' EXHIBIT.

Sulman & Picard Report May 5, 1903.

Sulman & Picard.

44 London Wall, London, E. C.

May 5th, 1903.

John Ballot, Esq., 607 Salisbury House, London Wall, E. C.

DEAR SIR:

Cattermole Process.

We beg to report results of experiments on the above process.

Expt. No. 7. This test was made on Broken Hill ore ground to 60 mesh. 1,000 grammes of ore *was* used in two lots of 500 grammes each, as the Gabbett mixer will not take more than 500 grammes, which portion was agitated with 600 cc. of 0.2% Sulphuric acid and 30 cc. of Soap emulsion. The emulsion was made up of 50% of oil and 2% Soap; the oil being a mixture of two parts of residuum and one part of parafline.

This charge was agitated about 10 minutes, half the time with the baffle, and half without. The two charges were then mixed and submitted to the rolling process in the Gabbett (without baffle) for a period of three minutes. This treatment yielded satisfactory granules.

The charge was then put through an upcast separator to remove the light sands.

1028 The heavier portion was rolled in a cylinder, especially made for the purpose. This however did not have any beneficial result, but on the contrary, rather tended to destroy the granulation which had previously been obtained. This is probably accounted for by the small quantity of ore used relative to the size of the cylinder so that during the whole of the rolling the granules were exposed to the air thus producing a considerable amount of float.

The charge was next put through the upcast and yielded

Concentrates	450 grammes
Tailings	504 "

The loss in total weight is due to a certain amount of mineral being left in the cylinder.

The original assay of the ore used for this test was as follows:

Zinc	15.93%
Lead	16.71%
Insolubles	48.35%

The Concentrates contained 6.6% of gangue, the balance being a mixture of Galena & Blende, which was not analysed.

The tailings assayed:

Zinc	1.09%
Lead	1.63%

1029 Neglecting the amount of ore left in the cylinder the recovery in the concentrates equalled:

Zinc	96.3%
Lead	94.85%

This and other experiments have led us to conclude that the rolling process in a separate cylinder might be omitted and that the whole process can be carried out in the Gabbett. A test was carried out on a similar class of ore with the object of determining the correctness of this view.

Expt. 8. As nearly as possible the conditions of this experiment as to the value of the ore, strength of the oil solution, time, etc., were maintained as in the previous test. After treatment of the two lots of 500 grammes in the Gabbett, the two products were mixed together and re-treated by rolling in the Gabbett, from which the mixture was passed direct through the upcast and the light sands taken off. The coarse product was then slightly acidulated and re-treated in the Gabbett for 7 minutes and again put through the upcast. This treatment resulted in three products which consisted of:

557	grammes	concentrates.
205	"	light sands from the first upcast.
200	"	tailings.

The original assay of the ore used in this test was as follows:

Zinc	15.86%
Lead	19.69%
Insolubles	39.9%

1030 The concentrates contained: 11.65% insolubles.

The light sands assayed:

Lead	4.29%
Zinc	1.88%

The tailings assayed:

Lead	2.24%
Zinc	0.91%

The final recovery therefore amounted to 96.4% of the Zinc, and 92.06% of the Lead, or a mean recovery of 95.1% of the total metals present in the original ore.

These encouraging results have decided us to erect a model plant on the Gabbett system which will be capable of handling probably 50 lbs. of ore per day. This plant is nearly complete, and will have

its first trial during the course of this week, the results of which will be immediately reported to you.

Yours faithfully,

SULMAN & PICARD.

1031 COMPLAINANTS' EXHIBIT.

Sulman & Picard Report September 24, 1903.

Sulman & Picard.

44 London Wall, E. C.

24th September 1903.

John Ballot Esq., 607 Salisbury House, E. C.

DEAR SIR:

Re Cattermole Process.

We beg to append report on the progress of investigation of this process up-to-date. Since our last report a very great amount of work has been gone through, both independently by Mr. Cattermole and by ourselves, aided by our assistants Messrs. Pudsey & Chapman. The work done may be summarized briefly by the letters we wrote you.

Firstly. On July 14th '03, advising you that the Cattermole process was completed to our satisfaction so far as the granulation step was concerned.

Secondly. Our letter to you of July 27th '03, advised you to complete the patent for the second or breaking down step as although the trials were not complete considerable progress had been shown in this direction.

Thirdly. On August 11th, we advised you to complete the
1032 breaking down process patent, and expressed the opinion that this second step now showed the prospect of being a considerable commercial success.

The work done has been so voluminous including many interviews with patent agents and patent counsel (Messrs. Terrell K. C. & Gordon K. C.) that we need only briefly refer to the chief lines of investigation. We enclose you herewith a tabular view which we drew out for the aid of counsel, setting forth the chief reaction involved in the Cattermole Process.

Firstly we will summarize Mr. Cattermole's independent work.

Nagyag Ore. (Poor.) Acid granulation apparently useless. Alkali granulation using emulsion of residuum oil 2 parts, paraffin one part, gave fair results. In this case emulsions and circuits containing natural soaps worked best.

Assays, original ore:

Gold	0 ozs.	2 dwts.	21 grns.
Silver	3 "	18 "	12 "

Concentrates obtained:

Gold	0 ozs.	11 dwts.	8 grns.
Silver	26 "	12 "	3 "

Tailings:

Gold	0 "	0 "	16 "
Silver	1 "	5 "	13 "

A second sample gave good granulation in the same type of
1033 circuit, but using as emulsion oil residuum 2 parts, paraffine 1 part. A richer sample of ore *was* worked upon the original assay was not taken, but the concentrates obtained showed:

Gold	6 ozs.	10 dwts.	6 grns.
Silver	45 "	14 "	16 "

Tailings:

Gold	0 "	3 "	22 "
Silver	1 "	15 "	8 "

A considerable interval ensued, during which time a complete experimental plant was installed. This consisted of a series of 6 circular glass vessels, each fitted with a revolving cone agitator, the necessary power being derived from a ½-H.P. electric motor. The series of agitation vessels were divided into two, one of four units, the other of two. With each of these sets an up-current separation device was placed in circuit for the purpose of the separation of the granules of mineral from the depleted tailings. The plant also included a mechanical ore feed, and a glass emulsion tank fitted with agitator, together with liquor reservoirs and return pumps. After a few weeks the whole plant was put in satisfactory running order, and the dimensions of all pipe circuits, rates of agitation etc., etc., satisfactorily fixed. A series of tests upon Broken Hill ore then followed and demonstrations of the working plant were given to yourself and friends associated with you namely, to Messrs.
1034 F. A. Govett, Mr. H. C. Hoover, Mr. W. W. Webster and also to patent counsel, Messrs. Terrell K. C. & Messrs. Gordon K. C. The plant operates as follows: The vessels and separation circuit are filled throughout with water, which may be either acid or alkaline, according to the requirements of the ore to be treated; in the case of Broken Hill a circuit of .2% sulphuric acid was employed. The dry crushed ore is fed by the mechanical hopper into the first cone agitator, where it also receives the due continuous addition of emulsion from the emulsion tank above. After receiving its due rolling agitation herein it continuously passes into the second vessel where a like agitation is given, thence into the third vessel and into the 4th. By this time granulation is well established and the fine sands and slimes are sufficiently clean to enable them to be removed; this is done by their continuous passage through the first up-current separator. The fine slimes are rejected and after settling the liquor is returned to the ordinary liquor circuit; then the heavy

sands, together with the mineral granules, are continuously passed from the bottom of the separator into the fifth and sixth cone agitators, where, by a continuance of the rolling agitation the mineral granules are so increased in size (and therefore in specific gravity) as to enable them to be finally separated from the heavy sands by passage through the second upcurrent separator.

1035 The concentrations of Broken Hill ore effected in this plant have been exceedingly satisfactory, both slimes and sands almost mineral free having been obtained, whilst concentrates continuously and automatically delivered from the exit tube have been of high grade. The plant has shown itself capable of continuous work and to have a capacity of about half a ton per 24 hours, although the vessels were of such small size, the glass agitators not exceeding the working depth of six to seven inches with a diameter of 4½ to 5 inches. If these dimensions be merely cubed there seems reason to estimate that such a larger plant would treat 50 tons of material per day. A sample of Rosebery ore was also treated in this apparatus, the material having been crushed to 60 mesh. This was a copper-blende ore and granulated well, yielding a particularly clean gangue, whilst concentrates obtained "broke down" excellently into separate copper and zinc products, by the use of a 2% soft soap solution with 2% of caustic potash. Here, as in other experiments, the fact was brought out that if emulsions containing only lighter paraffine oils be used instead of those containing "residuum" that weaker alkaline solutions are able to effect the breaking away of blende from the concentrates. This is, however, to some extent, counterbalanced by the fact that light oil emulsions for the same class of reason do not so readily granulate fine blende-containing ores, and that an emulsion containing heavy residuum oils is preferable to effect the ready cleaning up of zinc-blende ore slimes.

1036 We experienced considerable difficulty at first in determining the minimum mesh to which it was necessary to grind the Broken Hill ore experimented upon. We had several parcels crushed to various meshes by Messrs. Johnson & Sons. The first two parcels were ground to 60 and 120 mesh respectively, the 60 mesh sample appeared to work fairly well, but considerable difficulty was found in dealing with the 120 mesh product. In order to ascertain the reason of the difference, several assays were made.

The 60 mesh material gave the following results:

Gangue and insoluble	39.0 %
Lead	19.69%
Zinc	15.85%

A sieving test was also made which showed:

Remaining on 60 mesh	2.5%
" " 90 "	.5%
" " 120 "	43%
Passing through 120 mesh	54%

Whereas the 120 mesh material showed on assay:

Insoluble and gangue	62.35%
Lead	8.45%
Zinc	9.4%

A check assay on another sample of 120 mesh also showed:

Insoluble and gangue	66.55%
Lead	7.17%
Zinc	8.85%

1037 A sieve test showed:

Remaining upon 200 mesh	35%
Passing through " "	65%

The two parcels were therefore entirely different in nature, the 120 mesh product being so poor and differing so much from the original ore as to give rise to the suspicion that it had been derived by sifting the finer portions of the 60 mesh product, although strict instructions had been given that such a method of producing 120 mesh material was not to be followed. We were confirmed in our belief by the fact that fresh Broken Hill ore reduced to 120 mesh on the bucking table was found to granulate quite readily. Fortunately, the succeeding fortnight's experiments which were carried out, not only in the large test plant, but in a small independent Gabbett cone mixer, subsequently erected for experimental work, demonstrated that it was unnecessary to reduce Broken Hill ore beyond 60 mesh in order to secure excellent results.

A certain amount of fine material as well as coarse is necessary to the building up of coherent granules, but the sieve analysis of the 60 mesh material just quoted shows that upon crushing to this maximum mesh quite a sufficient amount of material finer than even 120 is produced for all granulation requirements. The first granulations obtained from a trial on the new plant yielded concentrates containing 20.85% of insoluble matter, i. e., gangue. Too
1038 much oil emulsion had been used in this case and by further reduction (to about 6%) granulation was found not to be interfered with, and the concentrates only retained 12.15% of insolubles. A still further reduction was made in the oil additions when it was endeavored to add oil emulsion in the proportion of about 5% of oil upon the actual mineral present in the ore. The concentrates obtained contained:

Lead	30.73%
Zinc	24.65%
Moisture	1.7%
Oil	5.35%
Insoluble	11.91%

The concentrates were thus of excellent quality, but the sands both coarse and fine were not quite freed from mineral. The fine sands were found to contain:

Zinc	5.115%
Lead	8. 19%

The coarse sands contained:

Zinc	3.07%
Lead	6.59%

It was found however that the coarse and fine sands which still contained mineral values, held these in a partially granulated state, and their inclusion in the sands was due,

(*a*) to insufficient granulation.

(*b*) to the difficulty of making an absolutely sharp separa-
1039 tion in the up-current separators employed. Mixing these two products together and reagitating them in vessels 5 & 6 of the trial plant, the remaining mineral contents regranulated yielded an almost absolutely sharp separation from the sands. We have here only briefly summarized granulation work done to date, although the actual experiments extended over a considerable period; details of many negative trials necessary to establish these conditions can be seen in our own and Mr. Cattermole's notes.

The results obtained however fully justify, we think, our advice to you to exercise your option with regard to the granulation portion of the Cattermole process.

We next devoted our attention to the "breaking down" invention and for a time had little but negative results to chronicle. Mr. Cattermole found great difficulty in separating the blende from the galena in Broken Hill concentrates; we pointed out that caustic potash was too expensive an alkali for commercial employment and requested him in future to confine himself to the employment of caustic soda. This alkali has the disadvantage of producing rather more insoluble soaps and emulsions and some investigation was required to fix a fresh series of minimum strengths for its use in place of caustic potash.

Again the use of plain paraffine emulsions had been discontinued for some time for granulation purposes in favour of emulsions con-
taining from a third to a half of their oil contents of residuum.
1040 This material, owing to its viscosity, was found to be less readily emulsified than paraffine and therefore to give greater trouble in breaking down. These unexpected results gave a temporary check to the development of the breaking down process (now generally referred to as "classification") and in order to economise time Mr. Cattermole worked mainly by bottle methods, independently of our own investigation aided by Messrs. Chapman & Pudsey in the endeavour to overcome this difficulty. Various forms of mechanical apparatus were devised by Mr. Cattermole and ourselves with the object of aiding the breaking-down liquors. Gabbett cones driven

at increased speed and supplied with additional rotating and stationary baffles were first used, but without success. A type of apparatus capable of even more violent agitation was then bought, on the type of an egg-beater, which gave slightly better results. In order to confirm Mr. Cattermole's contention that attrition of the granules with the breaking down liquor was needed to effect a separation, a small clean-up pan was bought from Messrs. Fraser and Chalmers and added to the trial installation. This certainly aided considerably in classification and the first definite result in splitting up the granules obtained from the trial plant into blende and galena products, was obtained in July, by Mr. Pudsey.

The zinc product showed on assay:

Zinc	42.35%
Lead	14.08%

1041 The lead product contained:

Zinc	9.91%
Lead	64.03%

Though neither of these products is sufficiently good the figures mark a considerable advance on anything previously done. Mr. Cattermole, in the meantime, came to the conclusion that it was impossible to separate the whole of the blende in one operation, but, that as in granulation, it was advisable to separate the fines (blende) firstly and to treat the product containing all the galena and the coarse blende with a somewhat stronger solution to effect the separation of the latter mineral. He also found that the breaking down solution should also be "fed" with a certain amount of fresh oil in order to prevent it from taking out too much of the oil held by the granules in the first breaking down stages. Many excellent separations were obtained by him on the bottle scale about this time, but we did not consider it advisable to analyse any of these products or to be content with any results not obtained by the mechanical means. Towards the end of July, working in the independent Gabbett mixer upon the lines just specified, Mr. Cattermole succeeded in obtaining the following classifying products:

1. Blende Slimes.

Zinc	43.12%
Lead	12.32%

1042 2. Coarse Blende.

(Representing the bulk zinc product.)

Zinc	44.6%
Lead	9.28%

The bulk of the lead product showed:

Zinc	6.45%
Lead	77.79%

These results again show further improvement. Jigging methods for the separation of blende from galena granules did not give such good results; the lead product remaining giving an assay of:

Zinc	16.8%
Lead	52.5%

Mr. Cattermole now devised 3 or 4 different types of beating separators which he constructed and experimented with, and which combined factors of violent agitation, a continuous upward but pulsating flow, and to some extent gradation and the separation of particles by the use of a cone shaped vessel. The results obtained, though giving indications of promise, were not sufficiently conclusive to permit us to advise you to continue experimental plant expenditures in this direction. At a later date, however, it may be advisable to go over a portion of this ground again. The use of residuum was now reduced to a minimum in the granulation process, paraffine being mainly employed; using such, and paying great attention to the rapidity of agitation employed in the breaking down process, and also the proportion to be observed between breaking down liquor and granules (these factors being established mainly by independent work done by ourselves and staff), Mr. Cattermole in August, finally produced the following classification results:

1043

Fine Blende Product.

Zinc	46.38%
Lead	8.003%

Coarse Blende Product.

Zinc	49.09%
Lead	4.48%

This when mixed together gave an average zinc product assaying:

Zinc	48%
Lead	6%

The lead product showed a contents value of,

Zinc	6.05%
Lead	66.59%

We need hardly say that we consider that these results, showing as they do that it is possible to obtain by means of Cattermole's process excellent smelting products, in both cases free from any smelting penalty, justified us in advising you to complete your option upon

the breaking down portion also of Cattermole's process. We do not propose here to give a detailed resume of all the experimental work done by us during this period, but we append one list of
1044 tabulated results upon Gabbett agitations as a type of the investigations. We may add a few remarks in conclusion. The acid process does not appear applicable to West Australian ore as typified by a sample of Oroya ore, where it appears necessary to dry crush and use a soap circuit; *now* has Mr. Cattermole been successful in granulating mineral from the highly complex Nagyag ores last obtained from Mr. Alexander Hill. These samples differ somewhat from those obtained by us in April and May from the Bergrath Steinhaus upon which, as already noted, good results were obtained. It is, however, very satisfactory to record the fact that the granulation of Broken Hill ore proceeds perfectly well in highly saline waters, made up by us to represent Western Australian water supplies, if .2% of acid be used in the circuit. We also enclose a tabular view of Cattermole and similar reactions, which were drawn up by us in July for the aid of counsel.

We are, dear Sir,

Yours faithfully,

SULMAN & PICARD.

(N. B.—Normal Revolutions of cone about 1,000 per minute.)

	Ore.	Pulp liq.	Emulsion.	Oleic acid.	Time.	Remarks.
	400 grms.	400 cc.	25 cc. 33.3% P. emuls.		5 mins.	Some separation.
	*of ½—½	of .2%	& soft soap.			Fines very dirty. Poor.
A².		Agitated again.		1 cc.	5 mins.	Great improvement but sands not clean some coarse galena free. Fair.
B.						Slightly better than A.
	400 grms.		25 cc. 33.3% & Oleic-		5 mins.	
	of ½—½		aad soap.			Great improvement even better
B².		Agitated again.		1 cc.	5 mins.	than A. In each case fine sands flocculent.
B³.		Further agitation.		1 cc.	5 mins.	Immediate improvement. Sands fairly clean slight floct. fines less galena free:
C.				None but 10 cc. of 10% ol. K. S. Neut.		Immediate Granulation.
	400 grms.	400 cc.		(oleicnad		
	of ½—½	of .2%	25 cc. 33.3%.	=(KHO neu-		Sands fairly clean not quite so as B³.
			(As in B.)	tral soap.)		
D.				10 cc. of	1 min.	Grann. fair, sands fairly clean.
	400 grms.	400 cc.	25 cc. 33.3% ol. NaS.	10% ol. NaS		
	of ½—½	of .2%		& Scc. 20%	2 "	same) Sands still dirty and
			(As in B.)	acid to neut.	5 "	same) flocculent
				free alkaline.		Better results therefore from C. experiment.

E.						
	400 grms. of ½—½	400 cc. tap water.	Same as D.	Same as D.	5 mins.	Fine diffused gran. sands clean & scarcely floc.
						Fines doubtful as they may be taken up with granules.
	(This Expt. to see if acid could be added after the emulsion.)					
E^2.		Further agitation			5 mins.	Same as above.
E^3.		made to .2% acid.		further agitation.	5 mins.	Improvement but sands dirty & blendy.
1046						
F.						
	400 grms. of ½—½	400 cc. .2% acid.	(8 cc. of paraffin instead of emulsion.)	mixture of with 10% ol. acid. soap in	5 mins.	Results no good.
F^2.				added 10 cc. of Neut.		Results greatly improved & fine sands fairly clean.
	(Soap wanted in emulsion.)			10% ol. NaS	5 mins.	
G.			15 cc. 33.3% (ol. NaS)			
	400 grms. of ½—½	400 cc. .2% acid.	& 10 cc. 10% ol. NaS.		5 mins.	Result bad.
			Another 15 cc. emulsions.			Result fair, only film.

(*I. e., ½ 60 mesh, ½ 80 mesh.)

Gabbett Agitations.—Continued.

	Ore.	Pulp lbg.	Emulsion.	Oleic acid.	Time.	Remarks.
G².		Further agitation.			5 mins.	
			30 cc. = 5% on min.			Very fine granular sands not clean.
G³.		Further agitation.		10 cc. of Neut. 10% ol. NaS	5 mins.	Greatly improved.
			(This Expt. confirms E.)			
H.	400 grms. of ½—½	400 cc. of .2% acid.	16 cc. of 50% R. P_2	20 cc. of 10% neut. ol. NaS	5 mins.	No good.
H².		Further agitation.			5 mins.	No good.
			(This Experiment going back on old thick oil emulsion.)			
I.	800 grms. of ½—½	800 .2% acid.	50 cc. 33.3% P. SS emuls.	4 cc. oleic acid.	5 mins.	This to see if any change takes place, agitation being different & pulp bulks same. Granulation only just commences, compare with A.
I².		Further 2½ mins.		making 7½ mins.	7½ mins.	Begins to lighten.
I³.		"		2½ mins. making	10 "	Granulation fair. Sands not quite clean. Showing that agitation is different.
			(This Expt. only differs from A. in bulk of pulp used.)			

J.						
200 grms. ½—½	400 of acid.	12½ cc. 33.3% emuls.	P. 88	1 cc.	5 mins. 10 "	Result poor. Same. This proves that although general conditions are same—more importance must be attached to type of agitation.
(Same as in A but only half proportion in relation to water.)						
K. (Same rations as in A but double bulk.)						
800 grms. ½—½	800 of .2% acid.	25 cc. 33.3% emuls.	P. 88	2 cc.	8 "	Granulation hardly started.
K^2.				10 cc. neut. 10% sl. NaS.	at 14 mins.	Granulation appears to start.
K^3.					17½ "	Fine diffuse of granulation.
Changed Agitation to Slow Rolling for further					2 mins.	Excellent separation & granulation.

(Shows enormous effect of changing (slowing) agitation type.

COMPLAINANTS' EXHIBIT.

Sulman & Picard Report November 19, 1903.

Sulman & Picard.

44 London Wall, London, E. C.

Received 20-11-03.
Partially Ansd. 23-11-03.

Nov. 19th, 1903.

John Ballot, Esq., Chairman, Cattemole Ore Concentration Syndicate, Ltd., 607 Salisbury House, E. C.

DEAR SIR: We beg to report to you upon work done since the date of restarting the experimental plant on October 8th.

Broken Hill Ore, 3 sacks of ore were freshly crushed by Messrs. Johnson & Sons to 60 mesh.

Plant. This was cleaned up, new rubber joints being fitted to all pipes, and a new full-way tap to water feed. The following
1048 defects were also remedied: iron pipes in sump removed owing to corrosion by acid and loss of latter. If found to be necessary they will be replaced by earthenware pipes. The spindle-bearings were renewed, but after short run, the wear being very apparent, it was decided to abandon the bottom bearing entirely. Gunmetal bearings above the cone were substituted, but the cutting action of the sands (garnet) together with electrolytic action between brass bearing and steel spindle so rapidly destroyed the latter that this method had to be abandoned. Brass spindles were obtained from Messrs. Still & Co. only the top bearings being retained in their entirety, but wooden blocks as rough guides were subsequently fixed below. So far this system has worked very well and is an important point gained in simplifying the larger plant.

The cone screw connections between the bearing shafts and spindles have now been soldered solid to the spindles, the former loose screw connection with india-rubber washers having given much trouble.

The exit pipe from the first series of mixers, into the first upcast, was found to be unsatisfactory when merely horizontal. It has been replaced by a bent tube, the top of the bend reaching the level of the top of the last cone. This change largely prevents blockage of the tube by ore, and acts as an air trap to a considerable extent.

3" pulleys were obtained to be fitted (interchangeable with
1049 existing 1½" pulleys) to mixers 5 & 6, in view of slower rolling having been found advisable for the completing of the "granulation" process on several occasions previously.

The Second upcast was increased in length to give a better separation and slightly increased in width. It was also fitted with a coned valve to aid in closer regulation of the downcast current. It was found also that if the delivery pipe from No. 6 mixer into the sec-

and upcast were permitted to dip below the surface of the liquor in the downcast tube of the latter, that much air was drawn down with the pulp which caused flotation loss of mineral in coarse sands. If the delivery tube be cut short exactly at top of upcast but little air difficulty is experienced.

Many other minor alterations made and defects remedied which need not be specified here, but of which note has been made for future application in regard to the larger plant.

The "10 ton" plant, (so-called, although until the first runs therein are made it is impossible to gauge, even approximately, its capacity per 24 hours), has been designed on lines shown by experience gained with the small plant to be the most desirable. 40 gallon earthenware pats with rounded bottoms are being specified as mixers, the number and disposition being the same as in the small plant, but with the addition of another series of 3 for retreating the coarse sands
1050 if such should be found necessary.

The small duplicate of present plant on order from Messrs. Still & Co., for Mr. Courtney, is progressing somewhat slowly. The spindle and bearings are made, as also are the brass collars and connections for the mixers. The glasses are in course of cutting and fixing. Messrs. Still inform us that they hope to complete the plant in about 10 days from date.

Emulsion used in following trials: Owing to the colder weather the R_3P_1 type was found to become too thick to flow freely thro' the small taps used to regulate the emulsion additions and R_1P_{11} 33% (=16½% Residuum & 16½% paraffine) with 3.3% soft soap and 63.7% water used. This emulsion was not quite so good a granulator for zinc slimes as the thicker, but had been previously found preferable for subsequent "breaking down" operations.

1051 *Broken Hill Grading Test (Ore Crushed to 60 Mesh).*

+ 60 mesh =	6.10%	This contains an abnormal proportion of "fines" for fair 60 mesh crushing viz: 56% passing 120 mesh.
— 60 + 80 =	17.35%	
— 80 + 90 =	9.40%	
— 90 + 120 =	11.00%	
— 120 + 200 =	31.00%	
— 200 (not actual "slimes")	10.00%	
"Water-borne" slimes =	15.15%	
	100.00%	

Original assay (Ref. No. 659):

Lead = 18.56%
Zinc = 16.21%
Insolubles = 44.75%
Silver = 14 oz. 3 dwt. 0 grs. per ton.

In the first run 500 grms. added to No. 1 mixer every 4 minutes and emulsion feed regulated to give about 4.0% of oil on mineral present.

Started in usual way by agitating 500 grms. ore in mixers 1, 2, 3 & 4 each with required oil addition, thereafter continuously running via No. 1 mixer only.

During this run stoppages caused by choking of upcasts with consequent loss of mineral in tailings.

Including stoppages 23 lbs. ore put through in 90 minutes (= 10,500 grms.).

1052

Concentrates won	= 4900	grms.	(47.6%)
Coarse sands	= 3705	"	
Fine sands	= 1690	"	
Loss (through choking, and remaining suspended in circuit)	= 205	"	
	10500	"	

Tailings Assay:

Coarse sands:

Lead	=	8.86%
Zinc	=	8.45%

Fine sands:

Lead	=	7.22%
Zinc	=	6.10%
Concentrates. Insolubles		16.5%
Lead recovery in concentrates		76.8%
Zinc " "		75.6%

Slight loss of oil in tailings owing to percentage of oiled mineral carried by them.

The acid water circuit was 200 lbs. (20 gallons) and before a run contained	0.24%	H_2SO_4
after " "	0.16%	"

Nagyag Tests:

A series of small trial tests was made on fresh ore supplied by Messrs. Alex. Hill & Stewart to ascertain whether this ore was amenable to Cattermole process. Mr. Cattermole made several trials previously, but expressed doubt as to whether the ores would
1053 prove tractable to the process.

The main difficulty experienced was loss of acid by calcite and other carbonates—acid being neutralized before granulation effected. This was overcome by starting with 0.1% acid water making the addition of ore and emulsion, then adding another 0.1% acid after agitation for some little time. Good shotty granules were separated by handworked upcast, leaving very fairly clean sands. The granules retained their shape after drying.

The main difficulty of loss of acid due to calcite has still however

to be faced and further work is required to ascertain whether neutral metallic salts, etc. can be used in place of acid. The soap circuit process (alkaline method) is inapplicable owing to the great destruction of soap by this particular ore.

The evolution of carbonic acid is also another great drawback, as mineral is floated up thereby; after standing (till liberation of CO_2 is complete), gentle rolling brings down and granulates the mineral, rendering it recoverable in an upcast.

Blinman Ore (Rfer. Nos. 669*a* & 669*d*):

Average copper ..... = 5.58%
Calcite in sample A..... = 67.30%
Calcite " " D..... = 58.20%

This ore was mainly chalcopyrite disseminated through a calcite gangue. (Some of the copper was in an oxidized condition
1054 (carbonate) in the gangue, and such of course would be irrecoverable by oil; nor could it be recovered by any other wet method of concentration known to us, or even by acid leaching methods owing to the excess of calcite. Ammoniacal liquors did not appear to withdraw the oxidized values from the tailings with any marked readiness.)

2000 grams were tried in large apparatus; ore mesh = 60 emulsion R_1P_1 (as before, addition being 5% oil on mineral. Acid circuit 0.1% H_2SO_4 at first agitation; after two minutes another 0.1% H_2SO_4 added; good granulation of coarse mineral obtained, but flocculation of slimes enclosing fine mineral particles occurred.

The gangue was floated off and the sands agitated further, both with and without oil; but the granulation was not sufficient to permit a sharp separation in the upcasts. The results of this first run were very poor.

Fines	76.5%	of original ore =	3.22%	copper.
Coarse	17.5%	" " =	5.32%	"
Concentrates won ...	6%	" " =	24.76%	"

The above test shows that upcast apparatus will require modification for various ores. Further work was suggested in this direction, and also as to the use of an alkaline circuit, but orders were received to proceed with Broken Hill work.

1055 Broken Hill trials resumed (Ore No. 659):

Acid circuit 20 gallons; started at 0.24% at H_2SO_4
do. after 2 days' trials 0.122% "

The object of this run was to see if it is necessary to retreat sands. Emulsion used, R_1P_1, oil = 4% on mineral. Test as before, 12 lbs. ore being used.

Concentrates won, 2470 grms. = 40.3% original ore.

Owing to choking up of upcasts two bad periods of separation took

place of 3 minutes each, giving undue proportion of sands in concentrates.

Concentrates won, Insolubles..... = 20.5%
do. oil (after drying at 100° C) = 3.5%

The latter figure shows too slow a feed from emulsion tank.

The fines, and coarse sands, were then mixed and again put through the apparatus without further addition of emulsion.

The fine sands separated in No. 1 upcast now showed:

Zinc ..... = 3.59%
Lead ..... = 3.84%

Coarse sands separated in No. 2 showed:

Zinc ..... = 5.94%
Lead ..... = 4.38%

The Concentrates together with the coarse sands and fines were now mixed together and retreated through the whole plant
1056 at the rate of 500 grms. per 3½ minutes; emulsion added at the rate of 1 cc. per minute, a total of 30 cc. being added in all.

Final retreated products:

Coarse sands 1,860 grms.

Assay:

Lead ..... = 3.84%
Zinc ..... = 4.21%

Fines 940 grms.

Assay:

Lead ..... = 3.52%
Zinc ..... = 2.97%

Recovered concentrates from tailings, 870 grms.

Insolubles ..... = 14.35%
Oil ..... = 4.60%

This conclusively shows the better retreatment products obtainable by addition of emulsion.

Summary of results:

Lead recovery ..... = 90.9%
Zinc " ..... = 89.4%
Total oil on concentrates ..... = 3.78%
Concentrates obtained ..... = 54.4%

Better extractions would be obtained,

(1) by making the feed from the hopper uniform and continuous instead of intermittent as at present,

1057 (2) more regular and more accurately quantified emulsion feed,

(3) return to R_3P_1 type of emulsions—which have consistently given better granulation than R_1P_1.

Amlwch Ore:

56 lbs. crushed to 60 mesh by Johnson & Sons.

Original assay:

Zinc = 18.06%
Lead = 7.74%
Copper = 1.7%
Gold = 0 oz. 1 dwts. 23 grs.
Silver = 6 oz. 8 dwts. 5 grs.

Grading test:

Stays on 60 = 2.5%
— 60 + 90 = 25.0%
— 90 + 120 = 12.0%
— 120 = 60.5%

A preliminary run on this ore showed that granulation took place to some extent in 0.2% acid circuit, using 5% oil on an estimated contents of 40% mineral, but with the addition of a little oleic acid; emulsion = R_1P_1.

2,000 grms. ore taken; and 0.5% more emulsion added in mixers Nos. 5 & 6.

Concentrates won = 22.5%
Insolubles = 23.6%

1058 Larger Run. 22 lbs. ore used, in 90 minutes:

Circuit at start 0.2% H_2SO_4
Circuit at finish traces only.
Emulsion R_1P_1; = 5% on 40% mineral.

The usual routine was followed, after 5 minutes preliminary agitation, 500 grms. of fresh ore being added to hopper feed every 5 minutes. Owing to the fineness of the ore the first upcast current was kept very slow, notwithstanding which large amounts of slime remained suspended in circuit and would not settle.

Most of the tailings were rejected in No. 1 upcast, but the concentrates and sands produced, although granulation was apparent, were but slightly removed from original ore.

Concentrates	= 17.01%	Balance being slimes held in circuit.
Insolubles	= 17.5%	
Lead	= 7.84%	
Zinc	= 21.04%	
Coarse tails	= 17.50%	
Zinc	= 17.20%	
Lead	= 6.88%	

Further trials are in progress.
We are, dear Sir,
Yours faithfully,

SULMAN & PICARD.

1059 COMPLAINANTS' EXHIBIT.

Sulman & Picard Report, March 4th, 1904.

44 London Wall, E. C.,
4th March, 1904.

Received 5-3-04.

Sulman & Picard,
44 London Wall, E. C., 4th March, 1904.

John Ballot, Esq., Chairman of the Cattermole Ore Concentration Syndicate, Ltd.

DEAR SIR: The work done since the date of our last report has been largely of a constructive nature, viz: the erection, alternation, running and testing of the Cattermole oil (trial) plant for Mr. Courtney (The Sulphide Corporation Manager) at Cockle Creek.

This plant has been built to your orders under our supervision and with Mr. Cattermole's assent upon inspection, by Messrs. F. M. Still & Co. and has been erected and run at their works at Charles St. Farrington Road.

This plant is now in efficient working order, tests having been made on Broken Hill ore "straight" therein, and is now to be taken apart, carefully numbered and lettered, and packed for despatch to Australia. Photographs of the plant have been taken, and copies of these will be numbered and lettered similarly, to aid in the re-erection of the plant in Australia.

This report will therefore deal mainly with the modifica-
1060 tions made in the Courtney apparatus as found advisable after experience with the original type plant erected at 44 London Wall.

(1) The apparatus was similar in general design but the ore feed was improved; this followed on a series of ore-feed experiments undertaken at 44 London Wall, the hopper being provided with a mechanical stirrer operated by a worm wheel on the top shafting.

(2) Mixers employed: These were in three tiers, four being on

the top row, three in the second, and two in the third; the last being for retreatment of coarse sands.

(3) The upcasts were made larger in capacity and were fitted one to each mixer tier.

(4) The cones in the last two mixers were driven from a second or counter shaft.

The details of the above plant are seen in the two photographs by W. Schuth, which are at the moment under duplication by Messrs. Vicars & Coy. Photos duly numbered and marked will be dispatched with the plant to Mr. Courtney.

With Broken Hill ore the new ore mixer permitted an even and easily regulated feed.

The new emulsion feed gave a sufficient flow without it being necessary to resort to air pressure; apparatus for this was, however, supplied in case of necessity.

The speed of the main shop shafting was 250 per minute and the speed of the fast (normal) cones, about 988 per minute.

1061 Owing to the increased size of the upcast, made in deference to Mr. Cattermole's suggestion as to the limited capacity of those based upon the first or smaller plant, it was found necessary to enlarge all the circuit supply pipes and to obtain a larger return pump.

In the retreatment mixers if the speed was fairly high the pulp did not flow out sufficiently fast unless the baffles were so placed that one of the legs was placed just beside the outlet tube on the further side of the latter, in order to deflect pulp into the exit tube.

It was necessary to constantly regulate the emulsion feed, owing to the exceedingly variable temperatures of Messrs. Still's workshop in which the trial of the plant was carried out. This was due to the proximity of brazing furnaces and forge—intermittently used—to our apparatus. This lack of uniformity of conditions greatly militated against the obtaining of the best results and acted prejudicially against any long continued runs.

The general results have been, however, on the whole highly satisfactory, and some of the best products ever obtained by the Cattermole process have been secured.

The original assay of Broken Hill ore used in these runs was as follows:

Lead	19.52%
Zinc	16.69
Gold	traces
Silver	14 ozs. 11 dwts. 6 grains

1062 The sample was ground by Messrs. Johnson & Sons to 60 mesh.

Run No. 1 (Monday, Jan. 25th, 1904):

Ore used, 35 lbs. rate = 22.1 lbs. per hour.
Emulsion used, 33.3% $R_3 P_1$, 3.3% S. Soap solution:

Rate of flow at starting, 8.1 cc. per minute.
do. at finish, 4.0 " "
Circuit at start = 0.24% H_2SO_4: 40 gallons in use.
do. at finish = 0.19% " "
Therefore loss of acid = 0.05% = 0.2 lbs.

The run was started in the usual way with 500 grains of ore in each mixer, and the separations were good at first, but finished badly owing to the drop in the rate of emulsion feed.

Concentrates won 18.4%. This unsatisfactory result led to the rejection of concentrates and sands without assay.

Run No. 2. A slower pulley was fitted to ore feed:

Ore used, 21 lbs. at rate of 14 lbs. per hour.

Emulsion used, same as before, but rate calculated to 4% on mineral present, i. e., assuming latter to be about 50%, but the oil feed fell off considerably soon after the start and had to be increased again towards end of run.

The run was carried out otherwise as usual, and the tailings retreated, but with no further addition of oil.

1063 Concentrates won, 46%.

Assay:

Lead	26.7%
Zinc	22.31%

Retreatment concentrates from Tailings, 18.45%.

Assay:

Lead	18.69%
Zinc	15.77%

Total concentrates, 64.45% very sandy.

Recovery:

Lead	80.4%
Zinc	83.5%

The general of this run was therefore very poor, the concentrates being poor and containing much gangue. The variation, however, of the emulsion flow was great—being from 3 to 10 cc. per minute. Another cause was due to the induction of air with mineral into upcasts. The various bends on the outflow pipes were altered several times until more satisfactory flows with a minimum of air inclusions were obtained; and it was decided that the granulation would be helped by the inclusion of more fine ore.

Run 3. (Independent of several small intermediate runs made to determine various factors in connection with the plant.)

Ore.—15% of fine ground Broken Hill ore was added to the main bulk of 60 mesh material, and a further bend put into outlet No. 2.

Emulsion.—Used as before, but with the addition of 1% of oleic acid. The ore put through was 25 lbs., at the rate of 14.2 lbs. per hour; the emulsion rate was 8 cc. at first, afterwards dropping to 6 cc. per minute. Total = 380 cc. = 3.8% of oil on mineral.

1064 Run started as usual by putting 500 grammes into each mixer, granulating this, and then opening continuous flow, No stoppages occurred during this run.

Flotation Factor Used.

The tailings were retreated as before, but on this occasion the course sands when passing through the last two mixers were allowed to be beaten well with air, by keeping the liquors low in the mixers and using fast agitation with baffles in. The concentrates were then found to be floated up in the upcast if only a gentle up current were used; the test thus started with granulation as usual, but the retreatment was partially affected by flotation. This was necessitated by the fact that flotation did occur to some extent in the first process, giving dirty sands which could not be completely cleaned by regranulating; the flotation cause of trouble was therefore used as its own remedy in the case of the last two retreatment mixer series.

Granulated concentrates won	= 41.4%	
Containing	12.8%	insolubles.
Retreatment concentrates	12.2%	
Containing	12.2%	insolubles.
Flotation concentrates	2.6%	
Containing	31.2%	insolubles.
Total concentrates won	56.2%	
Average insolubles	16.3%	

Fine tailings 26.8%.

1065 Assay:

Lead	3.29%	of which 1.31% oxidised
Zinc	1.41	

Coarse tailings 17%.

Assay:

Lead	3.71	of which 0.48% oxidised
Zinc	2.71	

NOTE.—This oxidised lead present is probably as a protective covering over the other lead left behind.

Recoveries:

Zinc 94.3%
Lead 92.2

Run No. 4 (Mr. Keating present part of time):

In this run the products were not retreated, but the last two mixers were kept low and the last upcast used for flotation separation. Ore (as in last run) put through = 24 lbs. at rate of 14 lbs. per hr. Emulsion 33.3% R_3P_1 3.3% S. S., 0.5% oleic acid; rate = 3.8% of oil on mineral present.

Acidity of circuit before 0.23%
after 0.20%

Volume of circuit = 30 gallons = 300 lbs.

Loss of acid = 0.09 lbs. H_2SO_4 = 8.4 lbs. per ton of ore. This, however, was not due to ore entirely, as the plain iron of the
1066 pump-plunger and one or two other iron connections were slowly attacked by the acid. This, will, of course, be easily remedied in a large scale plant.

Concentrates (total) 54.6%
insolubles 22.75%

NOTE.—Considerable trouble with emulsion feed during this run; but at one period a sample of concentrates taken before Mr. Keating and assayed showed only 10.5% insolubles.

Fine sands 28.2%

Assay:

Lead 4.64%
Zinc 1.54%

Coarse sands 17.2%

Lead 6.72
Zinc 6.12

Recovery:

Lead 87.4%
Zinc 90.7

These results were therefore on straight products without any retreatment; and the bulk result would have been much better but for the serious fluctuations of temperature and therefore the difficulty of regulating emulsion flow.

A portion of the coarse sands from the last test was re-
1067 treated through the last two mixers with the addition of a little carbonate of lime.

The flotation concentrates obtained, 1.6%
contained 14.2% insolubles

and the coarse sands were reduced to

Zinc 3.44%
Lead 4.16%

Using these figures the corrected recoveries become

Concentrates won ..... = 56.2%
Lead recovery ..... = 87.8%
Zinc " ..... = 93.9%

Other tests followed on modified lines which will be reported under a different head.

We are, dear Sir,
Yours truly,

SULMAN & PICARD.

1068 COMPLAINANTS' EXHIBIT.

Sulman & Picard Report April 19, 1904.

Sulman & Picard.

44 London Wall, E. C.

Received 20-4-04.
Copy sent Mr. C. F. Courtney and Mr. Chapman April 22, 1904.

19th April, 1904.

John Ballot, Esq., Chairman, Minerals Separation, Ltd., 607 Salisbury House, E. C.

DEAR SIR: We beg to hand you herewith record of work done since the date of our last report.

The following samples of oleic acid were obtained from Messrs. Charles Lamb & Co., of 60 Mark Lane, E .C., and analysed with the under mentioned results:

Oleic Acid (tin)	56.6%	acid
Oleic Acid (bottle)	101.0	"
Distilled do.	96.6	"
Saponification do.	89.5	"
Red Oil	38.9	"

A further sample obtained 14/3/04 = 101.1% acid.
The latter was that selected.

The reason for two samples of the above shewing over 100% of oleic acid is due to the presence of fatty acids of lower molec-
1069 ular wt. than that of pure oleic acid, which, when expressed as the latter, give a somewhat higher reading—just as Sodium

cyanide expressed in terms of Potassium cyanide would show 1·32% of KCy.

A series of tests were made to demonstrate the recovery of oleic acid. Ore, water, and oleic acid were shaken together in the ordinary proportions, the weight of oleic acid used being carefully noted. The top liquor was poured off from the granulated mass and found to contain no oleic acid, all having been carried down by the mineral. The latter was now treated by shaking with warm 2% caustic soda solution, the resulting soap liquor drained off, and the residue also washed with a little distilled water, the washings being added to the main liquor bulk; the mineral, etc., was left perfectly free from even traces of oil (oleic acid). The soap liquor was now neutralised with Sulphuric Acid, the oleic acid being turned out and floating to the surface. This was collected and quantified by titration with caustic soda standard solution 99.1% of the quantity of oleic acid originally taken being shewn to be recovered.

This operation was repeated twice on the same quantity of oleic acid with precisely similar results, showing that the recovery of this oil from mineral is practically speaking perfect.

1070 The vanning experiments referred to in our last report were now continued. We endeavored to obtain the loan of the small 8′ Wilfley vanner (now dismantled) formerly in use at the premises of Wilfley Co. in Old Jewry, but without success. We therefore instructed our carpenter to make a small model 3′x2′ table, which was done according to our designs.

A series of demonstrations were made on this table using "dirty sands" obtained both from old material derived from Mr. Courtney's plant at Charles St. and from ore freshly granulated in the repaired Cattermole plant in our laboratory. Acid circuits from 0.2% to 0.5% H_2SO_4 were used, the necessary carbonate of lime (in the form of whiting) being mixed with the sands just as they were placed on the table. The great bulk of the mineral was removed in large black flocks and floated over the riffles into the slime launder where it was collected; the sands and a very small quantity of residual mineral worked off in the ordinary manner at the further end of the vanner. The separations, though exceedingly good, were not perfect for the following reasons:

(1) the table—and especially the riffles—were not long enough in the very small model employed.

(2) the carbonate was too finely divided, giving off almost all its gas at first contact with the acid water and leaving none to be generated further along the travel.

(3) the riffles were rather too high to allow the only feebly floated mineral to be carried over.

1071 The results however gave cleaner sands than we have ever obtained by other means and justified the trying of the experiment on a larger scale.

This was done at the works of the Wilfley Co. at Lever St., City Road, upon freshly prepared "dirty sands" in the presence of Messrs. Ballot, Webster, Gregory, and ourselves. Owing to the shortness of the time at our disposal no proper arrangements could be made for a

flow of acid circuit liquor on the 16' table used; nor was any continuous ore feed possible. The material was therefore fed on by hand and dilute (1%) acid sprinkled on the ore (mixed with ½% of whiting) just as it began its travel. Under these conditions a continuous test was impossible, but the results intermittently obtained were quite sufficient to demonstrate that the principle of flotation vanning was the correct solution of the difficulty hitherto experienced in cleaning up dirty sands.

The following are assay results on some of the products obtained.

(1) Test made on the small model table, dirty sands being fed on continuously from No. 2 up-cast; 0.4% H_2SO_4 being the acidity of the circuit, and ½% whiting being added, as a pulp, to the issuing sands.

Concentrates	20.75%	Insolubles
Tailings	2.4 %	Lead
	2.9 %	Zinc

The difficulty here was, in absence of proper appliances (time being too short to install these) the due admixture of carbonate and sands. Still, however, the results are very fairly good, bearing in mind the fact that the sands were purposely very heavily loaded with mineral.

1072

(2) Wilfley Test at Lever St.:

(*a*) Large test:

Concentrates, 34.1% ..... Insolubles

Tailings:

4.8% ..... Lead
3.95 ..... Zinc

In this test the difficulty experienced was in obtaining the uniform feed of acid; as before pointed out this was added by hand intermittently, and could only be applied at one part of the table. At the moments when the conditions were right the sands came off in absolutely clean lines, but when the deficit of acid occurred much mineral escaped into the tailings.

(*b*) A smaller test on the same table gave:

Concentrates. Insolubles 25.75%

Tailings:

Lead	0.70%
Zinc	0.75%

In a properly arranged vanning plant the latter results could be made absolutely continuous in our opinion.

(We refer to the remarks made in the Working Instructions prepared by us, and forwarded to Mr. Courtney with regard to "shaking

tables." We think these would answer even better than vanners of the Wilfley *of* Buss types. This can be tried by removing the riffles from your small model table and altering the motion from a longitudinal rocking motion to a sharp jerk or knock. The circuit water will be fed on as usual, but the table will be only very slightly
1073 inclined towards the slime launder and less circuit water will be required.)

After the conclusion of these tests and after the Easter recess, the plant at our laboratory began to be dismantled for removal to Aldermanbury Avenue. We were also engaged for many days in preparing the full working instructions for Mr. Courtney above referred to, a copy of which we have supplied to you.

Mr. Chapman left on Friday last, the 15th inst., for Australia, fully instructed by us and yourselves.

During the period of the re-installing of the plant we are carrying out a series of trials as to the recovery of Hydro-carbon oil (emulsion) from the concentrates.

The concentrates contain as a rule from 3 to 5% of oil—say averaging 4%. When these are dried up from adhering water the oil is hardly apparent or visible, and they are almost crisp and granular to the touch.

From 3% oil residues nothing is extractable by pressure and the means adopted for recovery of the oil must be moderate in cost. 3% of oil on the concentrates is equivalent to say 1½% on the original ore; 1½% of oil = 33 lbs. per ton of ore, 4% of oil similarly = 44 lbs. per ton of original ore or almost 4½ gallons. Taking the cost of oil at £6 per ton in Australia, 44 lbs. = 2/4d. per ton of ore, if none is recovered. There is therefore only a small margin available for recovery costs. Further the petroleum residues (as found by Mr. Cattermole) are exceedingly difficult to remove with any degree of completeness from galena; in this respect they differ materi-
1074 ally from paraffin oil, and as you will recall gave great difficulty in the breaking down process. We have tried very many experiments with soap solution, and soda caustic do., separately and mixed, from 1 to 10% in strength, but in every case 1 to 1½% of oil has been left behind. Each 1% of oil represents 7d. per ton on the original ore.

We have tried the effect of heat with these re-emulsifying agents on oiled concentrates and find this advantageous. Steaming in a press might give good results but we have no available apparatus to determine this.

We are trying the effect of emulsifying solutions under pressure and temperature and will report same to you shortly.

Yours faithfully,

(Sgd.) SULMAN & PICARD.

P. S.—We beg to return Kendall's specification herewith. There is of course nothing that interferes with your patents therein.

We also draw your attention to Van Meter's Aluminated Hydrocarbon oil process, which is being advertised somewhat largely in South America. It is a flotation process of the Elmore type but with

specialized apparatus. Van Meter's process is equally foreign to the patents held by you and we only mention it as putting our knowledge of the process on record with you. The better known oil processes (so far tried commercially) are

Robeon's: paraffin oil pumped through an ore pulp; now obsolete.

1075 Elmore: flotation by means of viscous hydrocarbon oils; also oiled belts and table apparatus.

Scammel: flotation by means of hydrocarbon oils thickened, etc., by means of Sulphur di-Chloride.

Kendall: flotation of graphite only, by paraffine.

Van Meter: flotation by means of thick hydrocarbons rendered more viscous by the employment of acid salts of alumina.

Owns the Everson patent.

SULMAN & PICARD.

COMPLAINANTS' EXHIBIT.

Sulman & Picard Report May 2, 1904.

Sulman & Picard.

44 London Wall, E. C.

Received 4-5-04.
Board 18-5-04.

May 2nd 1904.

John Ballot, Esq., Chairman Minerals Separation, Ltd., 607 Salisbury House, E. C.

DEAR SIR: We beg to report on a trial experiment on the Cattermole process of granulation to determine the effect of temperature.

In the "Van Meter" process (pamphlet) it is stated that, with the particular oil used therein,—viz., heavy hydrocarbons thickened with said Alumina salts,—at a temperature of 140° F., Zinc blende
1076 is not taken up. In order to ascertain whether this alleged fact would aid in the classification of Broken Hill ore by preventing the inclusion of the blende in the granules, a series of shaking tests was made at temperatures ranging between 50° & 90° C.

At the lower of these no marked difference was apparent, but when the temperature approached 80° C., it was evident that some mineral was escaping granulation. This from its colour appeared to contain more blende than before, and after two or three further trials the best apparent separation was passed through a small upcast apparatus.

The fines which floated off and the coarse material which fell were assayed with the following results:

Coarse:

Zinc 13.41%
Lead 11.58%

Fines:

Zinc 19.87%
Lead 22.58%

No separation was therefore effected; indeed the finely divided galena had resisted granulation even more than the blende, although not indicated by colour.

Nevertheless the effect of increased temperatures in preventing granulation of fine mineral was so pronounced as to perhaps make it worth while to investigate the subject further.

Though inapplicable to the separation of Broken Hill ore
1077 minerals, we think you would do well to take note of heat effects generally, and at some future time to determine the various temperatures at which the more commonly occurring minerals, at a given mesh, refuse to take up oil from the same emulsion.

We are now carrying out a series of concentration tests on Nagyag ore, on the lines indicated in our conversation with you this afternoon.

We are, dear sir,
Yours faithfully,

SULMAN & PICARD.

COMPLAINANTS' EXHIBIT.

Sulman & Picard Report May 18, 1904.

Sulman & Picard.

44 London Wall, E. C.

Received 18-5-04.
Answered 24-5-04.
Board 18-5-04.
J. B. 18th May, 1904.

Messrs. The Minerals Separation Ltd., 607 Salisbury House, E. C.

DEAR SIRS: In answer to yours of the 16th inst., asking for a detailed report of work up to date, we are unable to give you, by this meeting, full details of the work done, as much of it is still in hand and will be more suitably dealt with in the course of a few days, certainly by the end of the month.

Kindly, therefore, regard the present as a short interim
1078 statement.

Plant at Aldermanbury.—This is in efficient working order and several runs have been made along the older lines, but with certain small modifications.

Firstly: A different emulsion has been used, following on suggestions from Mr. Cattermole, namely R_1P_1 plus 20% of Oleic acid. This results in giving clearer sands, and the oil is somewhat more readily recoverable from the concentrates. We have experimentally used such mixtures ourselves, but one objection to it was the difficulty we found on a small scale of recovering the oil in suitable emulsion form. Doubtless this difficulty could be overcome, and we are undertaking a series of experiments with the same, in accordance with your wish.

Hitherto therefore we have preferred to use either Hydrocarbon oils with an absolute minimum of Oleic acid, or else Fatty acids free from Hydrocarbon admixtures.

Secondly: The other modification has been the driving of the 6th mixing vessel at lower speed, which is certainly a step in the right direction, so far as Broken Hill ores are concerned.

Clean Up of Dirty Sands.

This work gives considerable promise of early success. As foreshadowed in our last, we have converted the small model vanning table into a "Humping" table, and have removed the riffles. By this means on small samples of dirty sands we have been able to clean up nearly all the contained oiled mineral, and to produce sharp clean sands without the use of any gas producing carbonate 1079 etc., thus effecting considerable economy both in acid and carbonate. Under these conditions mere contact of the oil particles with air when exposed on the surface of the table is sufficient to ensure their flotation removal from the sands.

The representatives of Messrs. Anthony Gibbs, witnessed an exhibition run on the lines referred to in the three preceding paragraphs, and expressed themselves as pleased with the separations obtained.

Mr. Chapman.

We see the arrival of the S. S. "Oratava" at Adelaide was cabled on Monday last; Mr. Chapman is therefore (presumably) by now on the Central Broken Hill Mine.

Nagyag Ore.

Having obtained *in* the consent of Mr. H. A. Whittaker to experiment on samples of this ore, which he had stored with us, we undertook a series of trials. These are at present incomplete, and we should like your instructions to continue them. We have dealt with the ore on the lines of preliminary water, concentration, separating coarse crushed material from the slimes and submitting the separated coarse to vanning, by means of a plaque. A very fairly sharp concentration of the coarse material into sharp mineral and clean sands was thus obtained, assays of which have been made and will be given in the complete summary of these tests. The slimes

which contained high values in gold and silver, were submitted to oil concentration both by flotation and granulation. The first trials do not show a complete extraction of these slimes, but gave indications that a very close recovery is possible.

1080 In dealing with material of this nature we find that much depends upon the thickness of the slime pulps treated; if the pulps are too thick, which was the case in our first trials it is difficult to bring all the oiled mineral out, either by granulation or flotation, but by treating a more dilute pulp this objection is overcome. We have made many assays of the intermediate products obtained, which we propose to give in our complete report.

We take this opportunity of expressing our conviction that with the exception of Broken Hill ore, and occasional ores of this type, (that is, where the gangue and mineral are much of the same specific gravity) the legitimate sphere of any oil concentration process will more and more in future, be confined to the treatment of slimes. In other words preliminary water concentration must be used to the fullest extent to which it is available, and only such products as escape the action of water concentration should be submitted to the action of oil. There are many reasons for this which will at once be apparent to you; foremost amongst which are (1) The contamination of coarse material, either mineral or sands with oil, for which there is no need; secondly, the inutility of putting coarse material through plant demanding special attention, and thus diminishing the legitimate capacity of such plant, when such material can be dealt with in a simple and economical water plant.

The credit of making water concentration, thus, to a large extent applicable to ores which cannot be reduced by this means alone, will still belong to the oil process, whilst the economies are apparent.

1081 We are dealing with Nagyag ores on these lines; and you will do well to devote therefore, considerable attention in the near future to the treatment of pure slimes.

Yours truly,

SULMAN & PICARD.

COMPLAINANTS' EXHIBIT.

Sulman & Picard Report February 17, 1905.

Sulman & Picard.

44 London Wall, E. C.

Received 18-2-05.
Board 22-2-05.
J. B. 17th February, 1905.

Messrs. Minerals Separation Ltd., 62 London Wall, E. C.

DEAR SIRS: We are in receipt of your letter of today with regard to Schwarz's patent No. 23906 of 1904, and have considered the documents sent in connection therewith by Messrs. Boult, Wade &

Kilburn. We think you are quite safe, and that if desirable, any part of this patent which may be considered to infringe your rights can be stopped by reference to the existing patents which you have. We think, however, it is desirable that we should all see Messrs. Boult, Wade & Kilburn's representative, Mr. Ballantyne, on this point and would therefore ask you to fix an appointment at your convenience.

We have lately been struck with the fact which is already known to your staff at Aldermanbury and elsewhere, namely, the
1082 enormous aid to the oiling and granulation of minerals which is afforded by the increasing of temperature of the circuit. An ore that would barely granulate at a temperature of 12° C., with 3% Oleic acid will readily oil and granulate in about three or four minutes if the circuit be warmed to say blood heat. This can simply be effected by the use of a closed steam pipe or coil placed conveniently in one or more places in the circuit, or in the granulating vessel, and the slightly increased heating desirable can be thus very economically obtained. Not only is the operation more perfect with heat, but the capacity of the plant is enormously increased and we are inclined to contribute at least a portion of the excellent results obtained in the large tests in Australia to the higher temperatures prevailing there, compared with London. This point seems of such importance that you would do well to enquire of Messrs. Boult, Wade & Kilburn whether this is not worth protecting by patent; in any case we think you would do well to have a series of tests made to quantify the heat effect more accurately.

With regard to the clean up of dirty sands by other means than a table (more or less of the Wilfley type) fitted with air pressure jets. We have made a series of trials and small apparatus designed more or less on the principle of the hand plaque, which gives such excellent results upon the small scale. The first of these consists of a strip of linoleum about 3 ft. long and about 6 ins. wide; this was slightly dished into a very flat concave trough throughout its entire
length, and placed at a slight angle, the lower part of the
1083 linoleum trough dipping into the water. A suitable water spray or fine jets were placed over the trough to give a downward wash, and a slot, sufficient to permit the intercepting of any sands passing down into it, was cut across the width of the trough just below its entry into the water. Under this slot a separate vessel immersed in the water was placed to catch the sands. The whole trough was capable of being given a slow rocking or tilting or jerking motion from side to side.

A portion of the dirty sands containing oiled mineral values was placed at the top of the inclined linoleum trough, and a gentle reciprocal rocking or jerking motion from side to side was given to it; the sands were rapidly cleaned, and washed down the centre of the trough continuously, as they were swayed from side to side, whilst the mineral was rapidly floated off into the current of the water running down the centre of the trough, and was thus carried over the slot into the water beyond this where it could be collected; the sands on the contrary were intercepted by the slot and collected

separately. This apparatus gave remarkably good results, the sands separated being absolutely clean, but the difficulty was that the mineral "float" on reaching the water surface at the bottom had a tendency to be sunk again, just by the slot, and to be thus mixed again to some extent with the clean sands. With a little experiment this type of apparatus could no doubt be readily improved, and this difficulty overcome. The second type of this apparatus consisted

1084 in putting a second linoleum trough of rather greater width exactly under the first, and increasing the side rock of the apparatus to such an extent that the floating mineral was alternately carried over the opposite sides of the top trough and thus fell into the bottom, collecting trough, which was provided with a suitable receptacle to collect this; whilst the sands were sufficiently heavy not to be carried over the side of the top-trough but continued their downward travel to their own receptacle at the bottom of this. With one or two modifications this type of apparatus gives promise of excellent results; but we were unable by hand-rocking to get the motion so exactly uniform as to carry off all the floating mineral over the side of the launder without permitting the escape of any of the sands at the same time. No doubt with simple mechanical rocking apparatus this type of apparatus would answer well. A further type again of this consisted in having a perfectly flat upper strip of linoleum, protected on each side by a fillet of wood about ¼ inch in depth, thus forming an extremely shallow trough. Strips of wood ½ inch in depth and about 4/7ths of the width of the linoleum were tacked on to the latter from alternate sides with a slight downward angle. These fillets of wood acted as baffles, retarding the too rapid downward travel of the sands as the shallow trough was tilted from side to side. The ¼ inch fillet along each side of the linoleum was sufficiently deep to prevent the sand from being carried over it, but permitted the floating mineral readily to escape into the similarly inclined trough placed below it.

A fourth type of apparatus has also given excellent results.

1085 It consists in what may be termed a modified type of the Frue vanner. An endless india-rubber belt about two feet in length (with filleted sides to prevent the escape of material over these) was made to travel between its two stretching rollers at a slightly upward inclination. The belt was also capable of being given an alternating side shake or a similar rocking motion.

The dirty sands were fed in to the belt at a point about ¼ of its length above the bottom roller. Suitably disposed sprays or jets of water were placed at various distances above this sufficient to give a very slight and gentle downward current of water over the belt. In this way the mineral was floated and washed continually downwards into a receptacle placed beneath the bottom roller whilst the sands were constantly removed upwards by the motion of the belt and were taken off quite clean at the top of the belt as this passed over the top roller. A very slight inclination of the belt is necessary in order to prevent the fine sands from being washed downward with the slight water current.

These few details will be sufficient for anybody with mechanical knowledge and facilities to design one or more working apparatuses which will have a large capacity of output and will be simpler in construction perhaps, than the air blowing table which is at present the only apparatus in use for your purpose.

We are, dear Sirs,

Yours truly,

SULMAN & PICARD.

1086 COMPLAINANTS' EXHIBIT.

Sulman & Picard Report February 21, 1905.

Sulman & Picard.

44 London Wall, E. C.

Received 21-2-05.
Board 22-2-05.

J. B.

21st February, 1905.

John Ballot, Esq., Minerals Separation, Ltd., 62 London Wall, E. C.

DEAR SIR: We beg to report the results of analysis of sample of "fine" dirty sands from Aldermanbury Avenue, which were obtained from the Oleic acid run a short time ago.

The sample contained 11.84% lead, and 13.39% zinc; Oleic acid 0.51% iron present as Oleate (and therefore soluble in Ether) = 0.037% equivalent to 0.408% of iron soap, which is again equivalent to about 0.36% of combined Oleic acid. This analysis is instructive, showing that the dirty sands contained over one-third of their Oleic acid as iron soap. This is a curdy, sticky, substance, and doubtless it sweeps together into flocky masses, oiled mineral, and oil, together with gangue. We have noticed previously that, in the insoluble form, soaps do certainly tend to adhere to gangue. It is worthy of note that no lime soaps were found in the above sample.

It is rather too early to definitely sum up the full advantages or disadvantages of iron soaps, but these bodies appear to us to give rise to the following difficulties.

(1) They tend to grease gangue as well as mineral.

1087 (2) They are highly contractile and curdy bodies; i. e., when produced in dilute solutions they tend to shrink together into small curds or clots which may thus contain gangue, mineral, air bubbles, oil globules, etc., etc. It is highly probable that at least some of the loose flocks noticed may have a basis of iron soap.

(3) Loss of Oleic acid in the fine sands which contain iron soaps. It will be necessary for us to see whether iron soaps once formed can be broken up by treatment with dilute acid or alkali, for the recovery of their contained fatty acid. It would also be interesting

to see whether the oiled concentrates also contained insoluble iron soaps. We had a consultation yesterday with Messrs. Leechman & Higgins, and pending the institution of the instruction book have decided upon the following programme for immediate purposes.

(1) Mr. Leechman will make two tests with alkali and water on straight Broken Hill ore, using triangular separating pieces of wood fixed upon the end of the Wilfley table in order to get the sharpest separation of vanned products. We propose only to use only the smallest quantity of ore that is capable of giving a definite result on the Wilfley table in each case; say 15 to 20 lbs.

We also propose to repeat these trials two or three times in order to ascertain whether the separations can be judged sufficiently closely to ensure consistent results, and thus to accord reliable indica-
1088 tions as to the value of alkali versus ordinary water in vanning.

(2) Mr. Higgins will carry out a series of a few small Gabbett runs in order to determine the best combined time and temperature factor for Broken Hill ore used with straight Oleic acid.

We will select with him the most generally suitable factor resulting from the foregoing, and this will then be applied in the large plant in two runs, (*a*) run on 40 lbs. with the plant as arranged at present (*b*) run on a similar amount but with a fresh fine sand's upcast used only after the last of the series of Gabbetts. From the information thus derived we ought then to be able to make a standard run, on 1-cwt. or 2 of ore.

We may recall that since the last run of this kind proved unsatisfactory, the following improvements or alterations in the general process have resulted: (1) The discarding of emulsions of Oleic acid, and the use of the acid direct, thus permitting a uniform and easily regulated oil addition. (2) The locating of iron soaps, and the presence of considerable quantities of this in the dirty fine sands. (3) The method of protecting metal surfaces which we have worked out (and are still working at) in order to prevent the destruction of the apparatus and the formation of insoluble metallic soaps whilst (4) the question of temperature forces itself upon us as likely to have a controlling influence on the question of output.

(5) The proposal to use only 1 upcast at the end of the complete series of Gabbetts which will permit of a much longer clean-
1089 up period for the fine sands. These sands were very dirty in the last long run and all oil and metal values contained by them is entirely lost at present. In a series of over a dozen experimental runs which we have lately made in our laboratory we have proved that with small amounts of Oleic acid the fine sands and slimes can be absolutely cleaned from mineral, provided sufficient agitation be allowed. This fact, therefore, strongly supports the modification of the apparatus as proposed, namely, one upcast only (for the separation of the fine sands), and the employment of this only after the full agitation period of which the plant is capable.

We are therefore much better prepared for our next run than was the case when the previous attempt at a standard run showed the necessity for the foregoing improvements.

We return herewith Mr. Higgins' report to you bearing yesterday's

date, and with much of it we are in complete accord; but we do not consider it at all advisable at the present moment to go back to the use of cheaper oils for granulation, as this means the re-opening of the question of oil removal and breaking down on which so much fruitless work has been done in the past. It is proved that with oleic acid very much smaller quantities of fatty substance can be used than is the case with R_3P_1 and similar oils, that 80% of the oleic acid can be readily recovered (which is not the case with residual oils); and therefore the economical difference between the two types of oils is not sufficiently large to make it desirable to forego the ad-
1090 vantages which Oleic acid offers in regard to its recovery from the mineral, and therefore in breakdown. So much has to be done before even the Oleic acid process can be considered complete, that it would be quite a wrong policy to go back into all the troubles necessitated by the use of insoluble oils before finally completing a process which is thoroughly economical and efficient.

When this portion of your work is concluded then by all means reconsider afresh the old breakdown process, but we strongly advise against the latter for the present.

With regard to Mr. Higgins' remarks as to the use of oil process initially as versus water concentration by Wilfley of jigs, etc., this of course goes without saying. But no one is likely to ask you to concentrate an ore by oil which he can treat with commercial success by simple vanning, etc., as indeed is the case with so many lead-zinc ores, as you are aware. In the ore which Mr. Higgins examined initial water concentration would doubtless save the bulk of the lead, but heavy copper losses would cetrainly result.

As we have many times pointed out to you, you by no means preclude yourselves (in using your process) from the employment of previous water concentration, and would doubtless use or devise a combination of the processes according to circumstances. We only refer to this point again as Mr. Higgins in his report seems to unduly labour the matter.

We should like Mr. Leechman, as soon as he has finished the alkali vanning test, to fix up the small centrifugal pump we left at your office. This apparatus, we think, will approach more nearly
1091 to the beating action of a shaking test than does the present Gabbett.

Finally we have advised Mr. Higgins as the next point of importance, on which attention ought to be centered (before any further work on cheaper oils is attempted) is the treatment of ores containing carbonates as typified by Nagyag and Blinman ores; (also Leroy ores). We have had some preliminary talk on this matter and will advise you as to further progress.

We think this exhausts most of the suggested work put forward up to the present, and propose you would be good enough to let Mr. A. O. Williams write up the necessary precis as to this (contained in this and previous reports) in the triplicate instruction book.

We are, dear Sirs,

Yours truly,

SULMAN & PICARD.

COMPLAINANTS' EXHIBIT.

Higgins Report March 2, 1905.

Copies sent C. F. Courtney & Geo. A. Chapman 3/3/05.
Received 3/3/05.

Report on the Conditions of Granulation.—March 2nd, '05. Preceding work having proved that the temperature at which granulation is effected has a great influence on the duration of agitation
1092 required, instructions were received from Mr. Sulman to determine the rate of charge of granulation with temperature. During these experiments the influence of other conditions was sufficiently marked to suggest to me their importance in altering the time of granulation, and these conditions have been carefully examined.

The Influence of Acidity.—Our experiments here confirm those of Mr. Chapman in Australia, viz. that an increase of acid in the circuit causes a decrease in the time required for granulation. There is only one slight objection, which becomes noticeable when the solution is heated, viz., a slight evolution of sulphuretted hydrogen due to the solution of the sulphides. The iron pyrites may be the delinquent, which would account for the large percentage of iron in the circuit, reported a short time ago.

It will be seen from the curves that the influence of acid is much greater at lower temperatures than at higher.

Influence of heat.—An increase in the temperature of the solution causes a decrease in the time of granulation. This is very marked, from a temperature of 8 or 10°C to about 40°C when an increase of temperature does not cause a very great decrease of time. The effect is startling when the former are compared with the latter. The curves below 10°C are not at all reliable since the time required for treatment was so long that the temperature had risen to air temperature at the end of the experiments. Two curves are also plotted show-
1093 ing the decrease in time with increase of temperature when ferrous sulphate contaminates the circuit. Below a temperature of about 23°C the ferrous sulphate causes an increase in the time of granulation but above that, it appears to decrease the time. These red curves, however, are not to be depended on so much as the black ones, and the differences in their slopes may be due to alteration in the speed of the cones, also to inaccuracy caused by a slight difference of temperature in the four mixers.

Experiments.—Granulation in the 6 mixer plant with 1% and 0.49% acid contaminated with ferrous sulphate. Oil used 1.5% oleic acid on ore.

Temp. of solution.	Time required to granulate.	Acidity.
17°C	19 min.	1%
17C°	17 "	"
21C	13 "	"
24°C	6½ "	"
28°C	5 "	"
29°C	3 "	"
19°C—20°C	28 min.	½%
23 —24°C	18 "	"
29 —28°C	12 "	"

These results are plotted in red on sheet 1.

The second series of experiments were carried out in the single Gabbet of the same size and construction as those in the 6 mixer plant.

1094 Acidity of solution used i. e. tap water with 1%, ½% and ¼% acid as indicated. Oleic acid 1.5% on ore. Quantity of water 1500 cc. Quantity of ore 500 gms. (in all cases Broken Hill 60 mesh). Speed of cone 900 revolutions per minute.

Time in minutes required for granulation.	Temp. of contents of Gabbet at start of agitation.	Acidity of water.
2½	46.5°C	1%
2¼	39 "	"
4	28 "	"
7½	20 "	"
11	10 "	"
32	5 at the start.	
	9.5°C at finish	"
3¼	53°C	½%
6	35.5°C	"
7½	24 "	"
11	10 "	"
20	2.5 at start.	
33	8°C at finish	"
4	57.5°C	0.25%
8	36 "	"
12	31 "	"
22	17 "	"
30	11 "	"
35	2°C at start.	
	7.5°C at finish	"

1095 The oleic acid which we are using begins to solidify at 12° C. and continues so doing until 0° C. is reached when it is almost solid. Obviously a solid oil is not capable of oiling a surface. Thus granulation cannot be expected when the temperature of the solution falls below the solidifying point and this fact may explain the great length of time required at low temperature.

Influence of the Thickness of the Pulp.

Starting with a thick pulp i. e. 1 of ore to 1 of water, the time of granulation is long and decreases as the proportion of water to ore increases, but, between 2 and 3 of water to 1 of ore the rate of change makes a great alteration and after the latter proportion becomes nearly constant at all proportions of water.

Experiments.—Acid Tap water, ore, oleic acid, &c., as in last series.

Water.	Ore.	Time in minutes.	Temperature.	Acid.
1000 cc.	1000 gms.	20 not finished.	29°C	1%
1500 cc.	1000 "	16	30°C	"
1500 cc.	750 "	7	30°C	"
1500 cc.	500 "	5	30°C	"
1500 cc.	250 "	4½	30°C	"
1500 cc.	100 "	4	30°C	"

Results plotted in black curve on sheet II.

1096 Influence of Peripheral velocity of cone.—An increase in the peripheral velocity of the cone causes a decrease in the time required for granulation, a point being reached after which this decrease is slight. Further experiments are to be carried out on this subject to determine the influence of friction of the sides of the Gabbett on the peripheral velocity of the cone. The speeds should also be taken still lower.

Revolutions per minute.	Peripheral velocity in feet per minute.	Temp.	Time.	Remarks.
1100	1008	13°C	12 min.	
1430	1310	12.5°C	10 "	
860	788	12°C	16 "	
840	780	27°C	4½ "	
1075	985	26°C	4½ "	
1070– 945	....	27°C	5 "	speed retarded.
570	522	28.5°C	7½ "	neglected.
1462– 900	....	26°C	10 "	do. neglected.
1462	1337	27.5°C	4 "	
1462	1337	26°C	4 "	

Acidity 1%, ore 500 gms., water 1500 gms., oleic acid 1.5% on ore. Results plotted in red on sheet II.

There is one thing to be noted in all these experiments, viz, that the point at which granulation is complete is arbitrary and has to be judged by the appearance of the Gabbett contents, this can
1097 be done by practice but is not exactly a perfect method.

Experiments are also to be carried out on the influence of

the quantity of oil present in order to complete the information regarding granulation.

Instructions have been received from Mr. Sulman regarding the influence of the size of the mineral.

A. HOWARD HIGGINS.

COMPLAINANTS' EXHIBIT.

Minerals Separation Letter, March 3, 1905.

Minerals Separation, Limited,

62 London Wall, London, E. C.

March 3rd, 1905.

H. L. Sulman, Esq.

DEAR SIR: As requested I send you enclosed Mr. Higgins' Report dated 2nd inst. The diagrams referred to therein have not yet come to hand, but I will at once forward to you on receipt. I am, dear sir,

Yours truly,

A. O. WILLIAMS, *Secretary.*

1098 COMPLAINANTS' EXHIBIT.

Sulman & Picard Report March 3, 1905.

Sulman & Picard,

44 London Wall, E. C.

Copies sent C. F. Courtney,
Geo. A. Chapman 3-3-05.—
Received 3-3-05.
Board 19-4-05.
J. B.

3d March, 1905.

John Ballot, Esq., Minerals Separation, Ltd., 62 London Wall, E. C.

DEAR SIR: I beg to acknowledge receipt of copy of Mr. Higgins' report from you this day together with curve diagrams, both of which are returned herewith.

I am in full agreement with Mr. Higgins' report, only a few remarks being called for.

Page 1. Influence of Acidity.

We do not think that the iron pyrites is responsible for the production of sulphuretted hydrogen on being heated with 1% acid, so much as is the ferruginous blende. The formation of H_2S bubbles in this way, is, of course, the basis of the Potter and Delprat processes

for separation of blende, and experience has shown us that ferruginous blende is more readily attacked by hot dilute acid than is pure blende. The large percentage of iron in the circuit liquors
1099 noticed of late is more probably due to the action of an acid upon cast iron surfaces exposed to the acid circuit.

Page 2. The curves showing the effect of ferrous sulphate as aiding granulation in warm solutions, but retarding the same in cool solutions (as compared with circuit liquor free from ferrous salts) is most instructive, and should be examined more closely hereafter; the effect of calcium soaps also requires investigation. In writing to Mr. Chapman we would be glad if you would forward to him paragraphs in our recent reports bearing upon the question of iron soaps. Whilst they may aid in granulation we do not think that such aid may be of unmixed benefit. Whilst we are not certain of the point, it appears to be likely that these iron and other metallic soaps are responsible for a considerable proportion of the "flocks" noticed, and therefore for the production of dirty fine sands, as see our last report.

We are in full agreement with the rest of Mr. Higgins' observations, and may summarize the work now being done at Aldermanbury Avenue as the determination of the following factors.

(1) Influence of acidity on granulation.
(2) " of temperature on granulation.
(3) " of speed of Gabbett agitation on granulation.
(4) " of ratio of ore to liquor on granulation.

1100

(5) " of metallic salts on granulation.
(6) " of the size of particles and of the influence of slimes on granulation.
(7) " of the amount of oil on granulation.

The above factors are being determined on

(*a*) Oleic acid.
(*b*) Residuum oils.

Mr. Higgins' present report is therefore the first instalment of the above scheme of trials. The influence of the speed and type of agitator becomes a factor of great importance according to our recent experiments. Speeds of rotation (with a small Gabbett) varying from 3 to 500 revolutions per minute proved almost useless. We then made a series of baffles which were placed in the Gabbett and which were "solid," i. e., they occupied the greater free space of the Gabbett vessel from the glass sides up nearly to the working surface of the cone. They were found to be disadvantageous as they gave too violent agitation, and set up large eddy currents in front of each baffle, greatly reducing rotation speed of the liquor in the Gabbett and adding water friction to such an extent to the rotating cone, that the power required to drive the latter was more than doubled. On replacing these solid baffles by the ordinary type of thin rod baffles, the granulation period was much improved, and the power

consumed in driving the cone fell again to the normal. The number of revolutions made by the rotating cone shaft mean nothing
1101 apart from the average diameter of the cone. Hence all cone revolutions should be reduced to peripheral cone speeds, expressed in velocity in feet per minute, as has been done by Mr. Higgins. The importance of this will be manifest to Mr. Chapman in putting up the larger cones at Broken Hill.

We have also carried out a series of experiments with a small centrifugal pump in place of a Gabbett, to determine whether this gives a better form of agitation than the cone. Fearing the cutting effect of sharp sands on the blades of the centrifugal pump, Broken Hill ore which had been passed through a 120 mesh sieve was used.

The following figures were obtained by Mr. Leechman yesterday in comparison with the Gabbett, and show the latter to be distinctly preferable to the centrifugal pump, so far. In fact the figures are so conclusive that for the present we do not intend to continue centrifugal pump experiments. We may mention the centrifugal pump used was only a small one having about a 4½ to 5" chamber but it was speeded up to about 1,200 revolutions per min. The pumps therefore had a considerably higher peripheral speed than the Gabbett used in parallel tests.

1102

Ore used. B. H. 120.	Temp. °C.	% acid.	% oleic acid on ore.	Minutes.	Remarks.
(1) Bell jar & centrifugals ..	10°	.4%	1½	60	Slimes not properly cleaned.
(2) Gabbett	10	.4	1½	15	Rather farther than (1).
(3) Bell jar & centrifugal ...	50	.58	1½	9	Small granules.
(4) Gabbett	50	.58	1½	2	Well cleaned.
(5) Funnel & centrifugal ...	10	.4	1½	60	Unsatisfactory.

A series of tests were made on straight 60 mesh Broken Hill ore on the Wilfley table (in continuation of the hand-panning trials previously reported to you) in order to determine the difference between 1% caustic alkali and water in obtaining better separation on the table.

Three separate tests were made, under precisely similar conditions in order to eliminate errors of observation. Mr. Leechman carried out these trials and the "heads" selected in each case was that product which so far as could be optically judged was free from blende. The "cut" thus made between the products was not such as would be made in practice where more of the middling products would undoubtedly be included in the heads; but the comparative effects of plain water and alkali were able to be read more closely by this means. The following table (which is not yet quite complete, as it lacks the weight of tailings obtained in runs two and three) certainly shows

a distinct line of favor of the alkali in increasing the amount
1103 of sharp lead products at the expense of the middlings. It is too early yet, however, to base any economical argument upon these results, as the collected products require to be assayed in order to arrive at the amount of the respective metal saving effected in each case by water or alkali. The table will be completed in our next report.

	1.		2.		3.		Total.	
	Alkali.	Water.	Alkali.	Water.	Alkali.	Water.	Alkali.	Water.
Heads	2.1	1.9	2.	1.8	2.4	2.2	6.5	5.9
Mids.	5.3	5.5	4.	5.3	5.1	5.7		
Tails	10.5	9.75						

We have also devoted considerable attention to the treatment of Nagyag slimes and fine ores as this is a peculiarly difficult product to deal with, from the complexity of its mineral contents, the necessity which exists for recovering values (gold telluride) from the finest of its slimes, and thirdly, from the presence of such large amounts of calcite and soluble mineral products as to preclude entirely the use of an acid circuit, whilst the alkali process is almost equally inapplicable by reason of the immediate precipitation and flocculation of slimes on the addition of either soap or alkali. If Nagyag ore can be treated by oil any way such ores as Blinman, Le Roi, etc., will be easily solved by similar means.

In the case of Nagyag ore we found it impossible to oil the fine mineral sands in presence of suspended slime products. This was very marked even when minus 150 mesh material was used
1104 for the trials. On standing for a short time the pulps of such materials deposited marked amounts of fine pyritic and mineralised sands entirely unoiled, although varying large quantities of oleic acid or residuum had been originally added to the pulp, and violent agitation given.

We afterwards proved that this difficulty of oiling fine mineral was not due in any way to presumed slight oxidization of the mineral, and it became increasingly obvious that the finest (more or less slightly flocculent) slimes were taking up all the oil added to the pulp, and indeed acting as "interceptors" between the oil and the other fine material.

So marked was this effect that it has suggested to us the possibility that highly divided material, whether mineral, gangue, or oxide, has a tendency to oil, independent of the varying preferential tendency to become oiled that the larger particles or sands exhibit.

This fact has been noticed by us before in the treatment of fine Broken Hill slimes, in the small Gabbett, previously referred to. With the insufficient rotation speeds of the cone it was noticed, time after time, that whereas the coarse mineral refused to oil, and no separation of coarse mineral from sands was effected (i. e., no granulation effect of any kind was produced), the finest slimes had nevertheless cleaned up; thus showing in Broken Hills ore that the first

tendency of the oil under these conditions is to combine with
1105 the finest mineral rather than with the coarser. These trials have indicated to us the necessity for determining the effect of the fineness of the particles on granulation time and to suggest the possibility and even advisability, of submitting refractory slime and fine products to careful water classification before oiling. In the case of the Nagyag slimes we find that from 50 to 70% of material may be separated out, in a series of spitzkasten, from a pulp originally containing a material no coarser than 150 mesh. The very fine, but still sharp sands, thus separated by gravity, in a plain water circuit, are found to be capable of as immediate and easy oiling as the coarse sands, when once the most flocculent and obstinate slimes have been removed from them.

In the case of Blinman and Le Roi ores these finest slimes which hinder granulation would probably be so small in amount, or in contained values, that they could be rejected. But with Nagyag ores the finest slimes (containing substantial gold values) require treatment; and this appears possible by using a combination of the float and soap process, i. e., by what is generally known as the Froment process. A sufficiency of soap is added to the slimes to agglomerate them completely, and they are well agitated to insure their completest intermixture, then a small quantity of acid is well stirred in, and the usual "float" (derived from oiled mineral buoyed up with carbonic acid gas bubbles) results, and can be skimmed off.

1106 We have also tried the effect of agitating carbonated ore slimes with tar (wood and coal) with previously oiled galena concentrates, with wood dust, cork dust, etc., previously moistened with oleic acid, etc., but have not obtained such promising results as by (*a*) submitting the slime pulps to close spitzkasten classification, and treating the separated fine sands in the usual way and (*b*) treating the fine reject slimes by soap and bubble flotation.

In our next report we shall deal with the results obtained.

We are, dear sir,

Yours truly,

SULMAN & PICARD.

1107 COMPLAINANTS' EXHIBIT.

Mineral Separation Letter March 6, 1905.

Minerals Separation, Limited.

62 London Wall, Nos. 413/415.

London, E. C., March 6th, 1905.

Messrs. Sulman & Picard, 44 London Wall, E. C.

DEAR SIRS: Enclosed I send you copies of Mr. Higgins' Report of 2nd inst., and yours of 3rd inst., together with original reports. I

I have gone through the copies, but think it best to send the originals to you so that you may have an opportunity of checking the two. Kindly return the originals as soon as you have finished with them and oblige,

Yours truly,

A. O. WILLIAMS, *Secretary.*

1108 COMPLAINANTS' EXHIBIT.

Higgins Report March 16, 1905.

Copies sent C .F. C. & J. A. C. 17/3/05.
Copy sent S. & P. 6/4/05.
Received 17-3-05.

Further Report on the Conditions of Granulation March 16th, '05.

Influence of the Percentage of Oil.

The effect of diminishing the percentage of oleic acid is to alter the type of oiling; the higher percentages producing granules, and the lower ones froth. 6% of oleic acid on the mineral is sufficient to form good granules without much froth. This froth consists of insufficiently oiled mineral mixed with large quantities of air. As this percentage of oleic acid is decreased, the time for clean up of the sands is increased and more froth is formed. 0.62% oleic acid on the mineral is insufficient to form any granules and nearly the whole of the mineral comes to the surface, on stopping the cone, as froth. 0.2% acts in the same manner leaving the coarse sands with rather more mineral in them. (This is 0.1% on Broken Hill Ore.) In all cases the oil has been measured in cubic centimeters and the percentage calculated as though they weighed grams but as the specific gravity of the oleic acid is less than unity this is not the case and all percentages will be lower than those actually given.

Acid.	Oleic acid.	% of oleic.	Time.	Temp.	Remarks.
1.1%	15 cc.	3% on ore	4 min.	30.5° C.	Very little float.
"	7½ cc.	1.5% " "	4¼ "	31 "	Rather more float.
"	5.2 cc.	1.04% " "	6 "	31 "	Still more float.
"	3.1 cc.	0.62% " "	6 "	32 "	
"	1.6 cc.	0.32% " "	7 "	31 "	Float vastly increased.
"	0.5 cc.	0.10% " "	8 "	31 "	Float vastly increased.
"	0.5 cc.	0.1% " "	4¾ "	29° "	Not finished.
"	0.4 cc.	0.8% " "	6½ "	30.5° "	
"	0.5 cc.	0.1% " "	8 "	31° "	
"	0.5 cc.	0.1% " "	8 "	31° "	Weight of concs. 170 gms.
"	0.2 cc.	0.04% " "	8 "	32° "	Apparently not much different.
"	0.1 cc.	0.002% " "	12 "	32° "	Little worse.
"	none	none	7 "	32° "	Very little float.
"	none	none	10 "	32° "	More froth.

The froth in the last case was found to be due to some concentrates sticking inside the Gabbett cone from previous experiments.

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Details of Experiments.—Continued.

Oil.	Time.	Acid.	Temp.	Wt. of float.	Remarks.
None	(8) m	1.1%	32° C.	—	..... No froth, only slime.
	(16) "				
None	16 "	1.1%	32° C.	—	..... ditto.
1.2 cc. oleic....	5½ "	1.1%	31° C.	—	..... Some galena unoiled.
None	10 "	0.877%	31.5° C.	1.102 gms.	..... For assay.
.5 cc. oleic	12 "	"	31° C.	203 gms.	..... —
.5 cc.	12 "	"	32° C.	—	..... Very little float.
Balkhany					
1 cc. ditto	12 "	"	32° C.	—	..... ditto.
2 cc. "	10 "	"	32° C.	—	..... Very little float, small granules.
5 cc. "	5 "	"	46° C.	—	..... Less float.
1110					
.5 cc. paraffine..	15 "				..... Very little float.
Increased to 1%.		"	40° C.	—	..... Sands not quite cleaned with the
In stages	18 "				increase of oil.
		distilled water			
.5 cc. oleic	10 "	.877%	32° C.	—	..... Apparently not different.
		Tap water			
.5 gm. tallow...	15 "	.877%	40° C.	—	..... No clean up.
1.5 gm. " ...	15 "	do	41° C.	—	..... Very little granln.
.5 cc. oleic	10 "	do	31° C.	—	..... For assay of fine sands.

The quantities used in above expts. were Ore 500 gms. water 1500 cc.

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The products from the last experiment were:

Froth concentrates	242 gms.
Fine sands	55 "
Coarse sands	198 "

The coarse sands were cleaned on the placque by aeration giving:

Clean coarse sands	167 gms.
Concs. from coarse sands...	31 gms.

Allowing for 10% insolubles in the concentrates by froth, the concentration in that product is about 87%.

Assay of fine sands: 11% of ore treated.

Zinc	6.49%
Lead	12.64%
Insols.	61.35%
Silver	8 ozs. 16 dwts., 10 grs.

Giving a total concentration of—Lead 92%, Zinc 94%.

1111 The assay of froth concentrates from a previous experiment, weighing 170 gms. returned

Zinc	32.70%
Lead	28.75%
Insolubles	12.10%

Concentration:

Lead	56%
Zinc	69%

The froth was separated by stopping the cone removing it and the baffle from the Gabbet, allowing the sands to settle for about 3 minutes then inserting a funnel so that it dipped into the clear liquid, and pouring more water in, until the whole of the froth was floated over the sides of the Gabbet into a bowl placed underneath for that purpose. This also floated over some fine gangue which may account for the large percentage of insolubles in the concentrates.

Experiments on the separation of the froth are being made but so far no satisfactory method has been obtained.

A diminution of the percentage of oil when that oil is either paraffine *of* Balkhany crude oil, does not cause a similar frothing to the oleic acid, but a diminution in the size of the granules and an increase in the time required for clean up of the sands.

Other oils excepting melted tallow, the which is of no use, have not yet been examined for froth in small percentages.

Some experiments have been made using the same sized cone as in the experimental Gabbets but a much larger vessel, i. e., 7⅜"
1112 diameter and 7⅞" deep, holding 4000 cc. of water and 1333 gms. of ore. Other conditions being the same as in the smaller vessel experiment, the time had to be increased to clean up the sands. This evidently means that a worse proportion between the dimensions of the vessel and the cone exists when the larger vessel is substituted for the small one. Whether any proportion between the two or at the other side of the small one would give better results remains to be determined.

A. HOWARD HIGGINS.

1113 COMPLAINANTS' EXHIBIT.

Sulman & Picard Report May 3, 1905.

Sulman & Picard.

44 London Wall, London, E. C.

Copies sent C. F. Courtney & Geo. A. Chapman 5-5-05.
Received 5-5-05.
Board 25-5-05.

3rd May, 1905.

John Ballot, Esq., Chairman, Messrs. The Minerals Separation, Ltd., 62 London Wall, E. C.

DEAR SIR: We beg to hand you herewith a statement of the new method of oil concentration which we have been engaged in investigating and working out in detail, for the purpose of your forwarding to Mr. Courtney and his staff in Australia.

It will be best to start with a short statement on the principle on which the process depends.

In determining the lowest limit of Oleic acid which could be employed in granulating, it was found that granulation practically stopped at a range of about 0.5% of Oleic acid on the mineral (60 mesh Broken Hill), in an acid circuit somewhat below 1% in strength.

A certain amount of black mineral froth was, however, noticed as a result. On successively decreasing the amount of Oleic
1114 acid below .5% it was found that whereas granulation ceased there was a growth in the amount of mineral float-froth under these conditions, and that the production of such float-froth appeared to reach a maximum when about .1% of Oleic acid on mineral was used. This froth on collection was found to consist of oiled mineral slimes mechanically holding more or less coarse (oiled) mineral particles, the froth carrying between 70 to 80% of the total mineral present in the charge. The gangue slimes and the coarse sands are left quite white in the liquor below the froth, and the balance of the coarse mineral not caught up in the black froth, but remaining mixed with the sands, is found to have been efficiently oiled and to be capable of complete recovery from the sands by table aeration.

This important discovery naturally suggested an economical method for the recovery of Broken Hill mineral quite different from any employed by you previously. The froth produced is not due to any action of the acid circuit upon traces of calcite present in the ore; i. e., not to the liberation of any gas in the charge by means of the dilute acid employed in the circuit.

It has been located, on the contrary, to the air introduced by the Gabbett cone during agitation, the air attaching itself to the oiled mineral slimes and to a large proportion of the coarse mineral par-

ticles, although both these materials can only be coated with an infinitesimal amount of oil, i. e., Oleic acid.

1115 That the formation of froth is due to air inclusions during the agitation, and not to carbonic acid or sulphuretted hydrogen is proved by the following experiences:

(1) If it were due to gases other than air the froth should be as freely produced when .5% or more of Oleic acid is used; this is not the case, and goes to show that a minute proportion of Oleic acid is one of the factors in float froth production.

(2) Samples of 60 mesh ore have been agitated with the acid circuit liquor without oil, or Oleic acid, for a sufficiently long period to have decomposed any trace of calcite, etc., present in the ore. On the addition of .1% of Oleic acid thereto, and agitation by the Gabbett cone, the froth is produced just as readily as if fresh ore was employed.

(3) Sulphuretted hydrogen in quantities sufficient to produce the froth mass is conspicuous by its absence.

(4) Additions of whiting or of calcite to the original ore failed to give any more definite froth than was obtained on the simple ore without such admixture.

The production of froth is to some extent a factor depending upon the amount of mineral slimes present in the ore the samples of ore which contain a minimum of slimes (such samples being carefully powdered to 60 mesh, by "step to step" reduction, with careful trommelling off of the fines produced at each crushing), were

1116 found to give a considerably less proportion of froth and to leave more coarse mineral in the sands. Nevertheless such coarse mineral left in the sands was found to be quite sufficiently oiled, and to be recoverable by aeration upon the table.

It thus appears that whether a mineral sample crushed to 60 mesh contains mineral slimes in large proportion, or the reverse, the use of .1% of Oleic on the ore is quite sufficient to afford means of complete recovery.

In our experiments carried out in the single Gabbett mixer no emulsion of Oleic acid was used, but the latter was introduced from a burette, drop by drop, to the mass of pulp whilst in vigorous agitation. In these experiments 500 grammes of ore were used in about 1,500 cc. of liquor of acidity varying from ½ to 1% of sulphuric acid, the whole being heated to temperatures varying between 30° and 40° C.

The temperature factor is also a most important one in insuring efficient oiling ("oiling" in this case refers to Oleic acid) and in the production of froth. We now generally employ temperatures varying between 35 to 40° C. to obtain the best results. The time of agitation in the Gabbett also varies from 5 to 8 minutes, with the before stated proportions; during the agitation the formation of black mineral flocks can be traced even while the mass is undergoing rapid rotation. Directly agitation is stopped the black mineral float froth rises rapidly to the surface, and on standing for a few seconds,

1117 forms a layer of from 1 to 2 inches in thickness. Below this layer is seen the turbid white or pinkish white suspension of

clean gangue slimes, the coarse sands, clean in themselves but containing some coarse oiled mineral, remaining at the bottom of the mixer. By careful addition of water beneath the float the black froth (containing the bulk of the mineral present in the original charge) can be floated cleanly off over the edge of the mixer and recovered by draining or any suitable means. Should any slight amount of froth sink during this floating off process, a slight stirring by hand of the contents of the mixer will at once bring to the surface any such particles of sunk froth. The clean gangue slimes may now be poured off practically free from mineral, whilst the coarse sands can be tabled, and their mineral contents completely removed by aeration.

A very large number of experiments was carried out on this method, and the process was then tried as a continuous one. After several trials the type of apparatus illustrated in the accompanying sketch was arrived at, and is now giving excellent results (refer to diagrammatic sketch).

The plant consists of a series of Gabbett mixers fitted with the usual baffles, and speeded at from 1,000 to 1,100 revolutions per minute as regards the cone. These Gabbett mixers are identical in every respect with those used for the original Cattermole process, the first one being provided with an automatic ore feed, water circuit inlet, and an oil (Oleic acid or Oleic soap solution) feed. It
1118 communicates with three other Gabbetts in which the agitation is continued as the pulp passes through them in series, the fourth mixer discharging by means of a swan-neck pipe into a short launder placed almost horizontally and leading into a compound spitz-lutte separator. This spitz-lutte consists of three compartments, each provided with a small water up current, and a means for collecting the material deposited in the apex of each, which way be adapted as either continuous or intermittent. It is important to note that the junction ridge of each spitzkasten with the next is about ½ to ¾ of an inch below the surface of the liquor filling the whole separator. This permits of a perfectly free travel from one end of the spitz-lutte to the other of the froth which separates from the pulp directly the contents of the last mixer are discharged upon the short launder.

It is also important that the launder leading to the spitz-lutte shall at its point of entrance into the latter be perfectly horizontal, and exactly on a level with the water line of the spitz-lutte. Any rippling action which would otherwise occur would tend to sink some of the mineral froth.

We may here conveniently note that other oils besides Oleic acid may be employed in this modified recovery process, but so far as Broken Hill is concerned Oleic acid gives by far the best results. Petroleum residuum added as emulsion, paraffine oil alone, R_2P, and R_1P_2 emulsions, have also been used, and all give small proportions of float, but do not act nearly so vigorously or efficiently on
1119 Broken Hill ores as plain Oleic acid. Moreover, .1% of Oleic acid on the ore treated only amounts to some 6d. per

ton, even assuming no recovery of the Oleic acid, a question which we shall consider later.

Continuing the description of the apparatus. The Gabbett contents discharged into the launder are separated by the compound spitz-lutte as follows:

(1) The mineral froth which floats over the whole length of the spitz-lutte, escapes over an accurately rounded discharge rim at its further end, into a launder, which delivers it on to any suitable filter surface; a piece of sacking or coarse, well-washed twill, is all we have found necessary for this purpose.

(2) The heavy sands and all the balance of oiled mineral particles sink in the first compartment of the spitz-lutte. Here a sufficient up-current of water is introduced to prevent fine sands or slimes settling with the coarse sands and the mineral, the object being to obtain a product which on tabling by aeration shall contain no sands sufficiently fine to float off with the concentrates but to be cleanly and sharply delivered at the sand collection end of the table. By reason of the increasing width of the spitz-lutte.

(3) The fine sands are therefore deposited and collected in the second division of the spitz-lutte into which a small up-current is also introduced. This upcurrent tends to keep the fine sands product free from gangue slimes and also to prevent the falling of any mineral flocks from the float froth travelling over it, or to return
1120 such flocks again to the surface. Oftentimes the product settling in this second compartment, which is too fine to put over the table, has been found to be so free from mineral as to be capable of immediate rejection. Should it, however, contain mineral, this can be easily recovered by means to be described later.

(4) The third compartment of the spitz-lutte also provided with a gentle water upcast, is sufficiently large to permit of the settlement of practically the whole of the gangue slimes, so that the water escaping over the lip of the spitz-lutte carries only clean mineral froth and is practically free from gangue slimes and quite clear.

We have obtained gangue slimes so free from mineral that they have been rejected without further treatment.

Clean up of second and third spitz-lutte products when these contain mineral.

Both these products being too fine to put over the aeration table, as they would naturally be floated over with the mineral or air treatment, are dealt with in one of two ways.

Their total quantity is relatively small compared with the product which settles in No. 1 compartment and with the mineral froth removed. Of course the joint amounts of Nos. 2 and 3 products will depend upon the nature of the crushing initially adopted, but they may vary from as small an amount as 3% up to perhaps 10 or 15%.

For clean-up purposes they may be mixed together.

1121 Method A. This consists in simply again agitating in a separate Gabbett mixer, whereby any contained mineral, which is exclusively due to the sinking of a little froth mineral, is at once reliberated, and comes to the surface as float. This can be again recovered by passing over a small separate spitz-kasten. In

some cases, however, although but very small amounts of material have been dealt with, two or three agitations have been required to completely recover sunk froth. As the products are, however, generally so small in quantity a complete clean-up is not a matter of economical urgency as a rule, and one agitation will probably be sufficient for all practical purposes.

Method B. A quick and complete recovery in one operation is possible by blowing a current of free steam into the mixed products suspended in a due proportion of circuit liquor. The combined heating effect of the steam with the bubbling produced, completely separates every trace of float mineral which rises to the surface as froth, and when passed over another spitzkasten can be added to the bulk of the froth collected on the filter from the main operation.

The operations are therefore summarized as follows:

(1) Gabbett agitation in the usual way with 1% Oleic acid.

(2) Floating off the bulk of the mineral as froth free from sands and gangue slimes, on to a filter surface, the liquor from which at once returns to the main circuit.

1122 (3) The collection of coarse sand and the balance of the mineral in No. 1 division of the spitz-lutte; the product separated going direct to the aeration table for final clean up into coarse mineral and sharp clean sands.

(4) The fine sands and gangue slimes separated in divisions 2 and 3 of the spitz-lutte are mixed and cleaned up either by fresh agitation or by the action of a jet of free steam, the mineral obtained as float froth thereby being added to the main froth product.

The return circuit passes through a heating apparatus to keep the temperature up to from 35 to 40°C.

Mode of addition of Oleic acid. In the experiments first carried out in a single Gabbett mixer it was found that the Oleic acid could be added direct in the proper proportion without any previous emulsification, etc., but in the continuous plant this was found to be impossible, as three small drops of Oleic acid were all that was required for 60 grammes of ore according to the size of the burette drop which happened to be employed by us in our plant. Under these conditions we found that some mineral was swept from the first into the second Gabbett without efficient oiling and that other porions of mineral were doubtless unduly oiled, owing to the insufficiently rapid break up and dissemination of the oil drop.

Oleic acid emulsions in water are, as you are aware, unsuitable as they are difficult to prepare, are very unstable and require efficient agitation apparatus to keep them sufficiently mixed, and they
1123 tend to become thicker and un-uniform in flow after a short time. We have, therefore, returned to the use of Oleic soap solution with the best possible results. We employ merely a 1% solution of Oleic acid as soap, i. e., just neutralized with caustic soda. The degree of alkalinity of this soap is so small that it is at once decomposed by the acid circuit, without perceptible diminution of the acidity of the latter; the result is that the Oleic acid is thus liberated throughout the mass of the pulp to be oiled in a state of the finest chemical division, and the most efficient and uniform oiling

of the mineral particles is thereby insured. Further, instead of adding the Oleic acid at the rate of 2, 3 or 4 drops per minute to the Gabbett contents, 100 times this amount of Oleic soap solution is used, and permits of easy and exact regulation. We have thus obtained of late cleaner sands, and especially gangue slimes, than in any experiments where drops of straight Oleic acid were used.

This method also affords a further economy in Oleic acid, as both the float concentrates from the table and the float froth require to be "broken down," i. e., to have their Oleic acid removed by soda, as Oleic soap, before they can be vanned into clean blende and galena products. The soap solution resulting from this breakdown is all that is required for the initial oiling of fresh mineral by the above described process. The Oleic acid is therefore of necessity recovered in the process and in the state in which it is required for re-use.

1124 This is not undertaken merely for the purpose of recovering Oleic acid, but as a necessary step in rendering the concentrates fit for vanning separation into blende and galena.

One important point remains to be noted in the breaking down operation.

The caustic soda solution used should not exceed 1% in strength and should be made up with soft, or rain water, i. e., which shall be free from lime or other salts. Unless this precaution be observed the Oleic acid cannot be cleanly removed from the concentrates, as small amounts of insoluble calcium or other soaps remain mixed with the concentrates or attached as microscopic films on the mineral surfaces, and lead to considerable float losses when such imperfectly cleaned mineral is sought to be separated on the vanner or other table.

If the mineral products after breaking down be accurately sized to varying mesh, limits in a MacDermott or other sizer, we have obtained indications that separation into blende and galena may be obtained in upcast apparatus adapted to the varying products, instead of employing vanner tables; but we have not yet fully worked out this idea.

The size of the compound spitz-lutte employed by us in the above trials was 2 ft. 6 ins. in total length, 2 ins. in width at the narrow end, and about 20 ins. wide at the broad or discharge end. The three divisions were necessarily rhombic in top plan, but each was brought to a cone shaped bottom, the depth of plan, but each one being such that the average slope of the sides was between 50 and 60° in order to insure no sand or other product resting upon them.

1125 A further modification of the whole process may be as follows:

(1) The subjecting of the suitably crushed ore to a water grading separation into two products, the first product being sharp ore, the second containing all fine and slime ore. The subjecting the coarse ore to plain air flotation clean up in an acid circuit on an aeration table without the addition of any oil or Oleic acid.

(2) The before described oil and frothing method to be applied to the fine grade material in the manner before detailed. In any event, and whichever method be adopted, the consumption of Oleic

acid is now reducible to an absolute minimum and need not exceed at the outside a very few pence per ton.

It will be obvious from what has been said as to the necessary recovery of Oleic soap that the limitation of Oleic acid to .1% is by no means essential, and if better frothing and oiling of mineral is insured under Australian conditions by employing .2 or even .3% of Oleic acid in place of the .1% herein described, these amounts can be safely employed as they are recoverable to at least from 80 to 90%.

Standard large scale runs are in progress on both methods, but we regret that we shall not have weights and assays of products in time for despatch to Australia by this mail.

The efficiency of the process hardly requires these assay figures, as the cleanness of the products from mineral is sufficiently evident.

We are, dear sir,

Yours truly,

SULMAN & PICARD.

1126 COMPLAINANTS' EXHIBIT.

Cable, Hoover to Hyde, January 18, 1910.

Western Union Telegraph Company.

III WY N 45-28 Collect I extra 6:14 P. M.

London via Palo Alto, Calif., Jan. 18-10.

Prof. James M. Hyde, 2343 C St., San Diego, Calif.:

Canjearon	W. U. Code
Capestoulde	Can you come
London	London
Disoxidate	all expenses allowed
Igonmene	in order to see
Grabhuegel	process
Koetjes	working
and Directors	and directors
Corneille your	If the directors are satisfied your
Bisurcades	appearances
Frombolare	Will offer
Mussantium and	£1000 and
Disossato	expenses
Koolapel	for a year
In Modico or	in Mexico or
Demussamus	elsewhere
Digester	examination
properties	properties
Hoover care Mineration.	Hoover care Mineration.

1127 COMPLAINANTS' EXHIBIT.

Cable, Hyde to Hoover, January 20, 1910.

The Anglo-American Telegraph Company.

San Diego, California.

To Mineration, London:

Hoover	
Canjearson	Western Union Code
caperolan	Can come
fludiabunt	one month (?)
consension	very desirable
bevisichte	on private affairs (?)
fumidi	provided the opportunity is not lost
burenque	Can you
dissaeptos	telegraph funds to meet immediate expenses.

JAMES M. HYDE.

COMPLAINANTS' EXHIBIT.

Cable, Hoover to Hyde, January 21, 1910.

Jan. 21, 1910.

To James M. Hyde:

£100 will be telegraphed if you can leave during next week.

1128 COMPLAINANTS' EXHIBIT.

Cable, Hyde to Hoover, January 24, 1910.

The Anglo-American Telegraph Company.

Palo Alto, California.

"via Anglo."

Jan. 24, 1910.

To Mineration, Ldn.:

Hoover	
exertment	will leave
Klemhaken	during this week
dissaeptos	telegraph funds to meet immediate expenses
to	to
Sandiego	San Diego.

JAMES M. HYDE.

COMPLAINANTS' EXHIBIT.

Sulman & Picard Report February 24, 1910.

24th February, 1910.

John Ballot, Esq., Chairman of the Minerals Separation, Ltd., 62 London Wall, E. C.

DEAR SIR: We beg to report on research work we have done in connection with mineral flotation during the past two or three months.

1129 Such work arose from a consideration of the patents of E. J. Horwood (Commonwealth Patent June 13th, 1909) and the later one of F. Burnett Dick (No. 16667, Aug. 7th, 1908), both of which have been published. The subject matter of both patents is well known to you, and may be summarized as follows:

Horwood takes lead-zinc sulphide concentrates, etc., and submits them to an oxidising calcination at a temperature sufficient only to attack the lead particles, and to cover them with the layer of oxidised material incapable of flotation by oil.

Subsequent oil treatment therefore only removes the blende, and the separation is thereby effected. Horwood also claims to do the same by wet methods, and we think we have already reported to you that we consider our own work in this line to have been anticipated by Horwood.

F. B. Dick limits his method to the extraction of copper from oxidised ores. The ore is crushed fine and heated to redness in a reducing atmosphere, the ore being thereafter cooled in the same. The copper is found to be reduced to a form capable of flotation by small quantities of oil, when the pulp is submitted to the action of a gas. As you are aware, Dick, of Messrs. Johnson & Sons, has worked his patent in connection with the Elmore process.

We understand that a certain company is introducing the combined process of Dick and Elmore in Rhodesia, but that the Tanganyika people are considering a form of "metallising" copper

1130 into prills, and recovering the same by ordinary means of concentration.

The question of the validity of Dick's patent, as you are doubtless aware, has been open to considerable discussion. Others before Dick have reduced copper ores in the same way, and have recovered them by concentration; and at the date of Dick's patent oil flotation was a recognized method of concentration.

The obvious contention was therefore that from the state of the knowledge of the art, and the known facilities existing at the time, Dick's patent disclosed nothing new. We ourselves do not think however that this contention can be upheld, and we are inclined to think that Dick has a valid patent for the specific combination claimed by him.

Returning to Horwood's patent, you will be aware that Mr. Donald Clark's article in the Mining Magazine for January, 1910,

describes this in detail (page 56, etc.), and that on page 8 of the same magazine an editorial states that a patent covering exactly the same ground has been granted in the United States to H. A. Wentworth. This patent is No. 938732 of November 2nd, and is assigned to the Huff Electro-Static Separator Company, of Boston.

In carrying out investigations on the above lines we found the need of a frothing apparatus which would separate the froth sharply from the settled gangue without the use of spitzkasten plant, which is never satisfactory on the small scale for a sharp clean-up. We constructed several forms of apparatus, but finally adopted the sliding top-principle with an electrically underdriven agitator; this
1131 has proved a most excellent plant, and has been inspected by your Mr. Hoover. Mr. Sydney Stevens has recently worked it and expresses complete satisfaction with it. It would be well to have this construction in a larger size, and this we believe Mr. Hoover intends doing.

We may mention that simple as are the details apparently it took us a month or more to effectively work out. Inasmuch as heavy oil particles may still persist in the sunken gangue, it was necessary to devise some form of surface-tension apparatus for recovering these. As our space is limited, and spitzkasten plant is awkward to work on the small scale, we have constructed a new tube apparatus with mechanical ore feed, etc., through which the gangue residues can be passed. This gives in effect all recoveries that could be yielded by spitzkasten plant in a much smaller space, and in compacter form. It is in these two types of apparatus that we have carried out our experiments.

We have since November 10th, 1909, taken out five patents. We beg to hand you the official receipts for the same. They are as follows:

No. 26019 Sulman & Picard dated November 10th, 1909. This is for the wet sulphiding treatment of admixed oxidised ore particles. If the particles are not oxidised to start with they are submitted to an oxidising calcination, and thereafter to sulphide treatment by keeping the solution faintly acid with sulphuric acid, and adding sulphuretted hydrogen, or a small quantity of soluble sulphide insufficient in quantity to neutralize the acid; the lead particles and the copper particles, etc., are sulphided in preference to the oxidized iron and zinc particles.
1132 Such sulphiding is only superficial, but sufficient to take an oil film. This therefore promises to give a separation of lead, copper, etc., from zinc and iron, whilst the metals are oxidized. In one experiment (the best one) we obtained a recovery of a little over 80% of the lead from an oxidized Broken Hill ore, which was sufficient to demonstrate the possibilities of the application of this method. The details of the process are fully set out in the specification which we have instructed Messrs. Boult, Wade & Tennant to send you, together with the further following four provisional protections referred to.

Specification No. 28612 Sulman & Picard, December 7th, 1909.

This again is for the sulphiding of certain oxidized ore products, and has more especial reference to copper and lead.

In this case the sulphiding of the oxidized metal is performed dry and at a sufficiently high temperature on a furnace hearth; sulphur or pyrites being mixed with the charge, the copper, etc., takes up the sulphur vapors and becomes covered with a layer of more or less dense crystalline sulphide. This process may be regarded as analogous to Dick's process, except that instead of reducing the oxidized ore to the metallic condition it is converted to, or covered with, a layer of sulphide, and thereby rendered amenable to oil separation.

The details are fully set forth in the specification small scale tests made in bottles before the completion of the apparatus before referred to gave indications of good recoveries, but the time at
1133 our disposal has not been sufficient to make properly quantified tests upon various ores. Both these processes, and the preceding one, we suggest should now be investigated more thoroughly.

Whilst experimenting with ores containing low metallic contents, the difficulty of forming a coherent froth from a small amount of material was, as previously hitherto experienced. We found that the addition of a little lamp-black or other suitable form of finely divided carbon gave strong froths which were capable of supporting small quantities of heavy oiled-metallic particles.

Further, we have found that finely divided freshly precipitated metallic sulphides, especially those of lead and copper possessed the property of forming oil froths of considerable stability and volume. For example, if in treating copper ore, small amounts of copper go into solution, the addition of sulphuretted hydrogen to the pulps will precipitate the copper as finely divided sulphide, which then forms a heavy froth with oil, and is capable of giving a better float recovery than would be obtained without it.

The flocculent metallic sulphides thus produced acted better than lamp-black.

Both inventions were protected as follows:

"Lamp-black" No. 29364 December 15th, 1909. "Precipitated Sulphides" No. 29616 December 17th, 1909.

We should suggest work only on the latter at present. Here again, as most of the experiments were on the bottle scale, further work is necessary in mechanical apparatus.

1134 The last of the specifications is No. 30182 December 24th, 1909. "For the recovery of oxidized mineral substances by oil." In this invention we took advantage of the acid properties of oleic acid or other fatty acid to decompose carbonate ores, or to unite with metallic bases, i. e., oxides; the latter becoming covered with a layer of greasy insoluble "metallic soap" which is capable of adhering to air bubbles. The use of "metallic soaps" in regard to sulphide particles has already been suggested by us, but the difficulty was to get these sticky and highly dense and insoluble soaps to diffuse themselves uniformly in a pulp, and to get them to stick to sulphide particles. Moreover experience has shown of late years that sulphide particles can be more effectually floated by other means.

This invention however, is a new application entirely of the principle in regard to oxidised ore; and it is also new in regard to forming the "metallic soap" upon the particles themselves.

More oleic acid is required to effectively float carbonates than would be required for sulphide ores of the same value, because the carbonates chemically absorb much of the oil, and combine with it, whereas with sulphide ores the minute film was only a physical attachment to the particle.

Nevertheless the treatment of the recovered concentrates by alkali results in the recovery of practically all the oleic acid as soap solution, and the addition of sulphuric acid to this in the small equivalent proportions required, liberates the oleic acid for re-use
1135 on a fresh quantity of ore.

The amount of oleic acid employed by us on copper carbonate ores have varied from ½ to 1½%. In the latter case however, we recovered over 95% of the oleic acid for re-use by treating the concentrates in the way described.

Although fair amounts of froth were obtained these were illusory as regards the savings, i. e., a fair amount of green froth from a malachite ore was not attended with the same recovery as would have been the case with a sulphide ore yielding the same volume of froth. It was therefore necessary to treat the sunk material in the tube, i. e., to employ surface tension methods rather than frothing. Combining the two methods, from a Rhodesian copper carbonate ore containing 8% of copper the best recovery obtained was 82%. The method is fully described in the specification, and may well form the subject of further research.

During the past month our time has been occupied to a considerable extent with other investigations, and we have already informed you of work we have been doing with regard to the concentration of a Finnish ore; complex lead, copper, zinc, sulphides. Though the experiments are not complete, the results so far obtained are encouraging.

We are dear Sir, SULMAN & PICARD.

1136 COMPLAINANTS' EXHIBIT.

Letter, Minerals Separation to Hyde, March 2, 1910.

Dictated to M. E. P. by J. B.

Enclosures

Minerals Separation, Limited.

62 London Wall.

London, E. C., 2nd March, 1910.

James M. Hyde, Esq., 62 London Wall, E. C.

DEAR SIR: As explained to you, a private syndicate has been formed in connection with my Company, for the special purpose of

exploring the Republic of Mexico, with a view to finding mines, ores, dumps or tailings, preferably amenable to profitable treatment by the Minerals Separation processes—and to endeavor to acquire such mines, ores, dumps or tailings wholly or in part, if such can be done on sufficiently advantageous terms, or to secure the adoption of Minerals Separation processes by mine owners under royalty, in cases where a direct interest cannot be acquired—and if successful to form a larger Company to handle the interests so acquired.

To give effect to this, and after fully discussing the policy with your goodself, it has been agreed to retain you to give your services exclusively to make the necessary investigations in Mexico, and carry out the object and intention of the Syndicate to the best of
1137 your ability, on the following terms and conditions.

That you will, as soon as directed, proceed to the City of Mexico, and, after conferring with the Syndicate's agents and friends there, devote the whole of your time and your best endeavours to carry out the work and without delay visit all the most likely districts and individual mines in the Republic, or such mines and districts as you may from time to time be directed to do, and carefully inspect their ores, dumps, etc., to ascertain quantity in sight, the value by careful sampling and treatability by Minerals Separation process as far as that may be possible, with the field apparatus you will be provided with. You will also ascertain, as far as possible all local conditions governing labour, supplies, transport, market for products, water, fuel, power, etc., which may have a bearing on the possibilities of successful mining or treatment operations.

You will fully, faithfully and concisely report in writing all results and information, so soon as obtained, together with your views and recommendations, direct to the Syndicate, or to the Chairman of Minerals Separation Ltd., 62 London Wall, London, E. C.,; in all other respects all such information obtained shall be retained by you in strictest confidence and shall not be communicated or disclosed to anyone, except on written authority from the Syndicate, Messrs. Lazard Bros., or the Chairman of Minerals Separation Ltd.

If any property, or properties, are found which you con-
1138 sider likely to suit the purpose of the Syndicate and for that reason to be worth further investigation, it may be desirable, in addition to such investigation, to arrange to send to England a bulk sample of the average ore for test and treatment, which you will accordingly arrange for and consign to Minerals Separation, London, through Messrs. Lazard Bros., of Mexico City, or as they may direct.

For the purpose of this undertaking, and to enable you to test ores on the spot, Minerals Separation will disclose to you its various processes, and give you all information in connection therewith, you undertaking to keep all such information confidential, and not to make use of any of it for any purpose except that of the Syndicate, and further you undertake and agree to communicate to that Company (Minerals Separation) any ideas for the improvement, modification, or addition to the processes, mechanical or otherwise, which may occur to you, or which you may make, and such shall be the sole property of the Minerals Separation, and you will immediately,

or whenever called upon, sign all documents necessary to protect the same by patent, if so desired, and to convey the title to that Company by assignment or otherwise.

The agreement shall be for a period of one year from 1st Feby. 1910, the Company reserving the option to continue your services for another year on terms to be mutually agreed upon.

The consideration for the services to be rendered by you
1139 shall be at the rate of £1000 per annum, payable monthly, or quarterly, as you may desire. The Syndicate shall also pay all your reasonable travelling and other expenses connected with the business—of which proper account shall be kept, and rendered monthly or quarterly, it being understood that such travelling and other expenses shall be kept within the limits, justified by the spirit and intention of the expedition.

In the event of any desirable business offering you shall actively assist any of the Company's or Syndicate's agents, or representatives, in carrying on any negotiations for dealing with or acquiring the same—no definite or binding negotiations for properties to be undertaken by you without the Syndicate's authority—nor are you in any way to commit the Company or Syndicate to any undertaking or responsibility without their previously obtained written authority.

If you accept the engagement on the foregoing terms and conditions, I am authorized to confirm the agreement for and on behalf of the Syndicate, in the name and for and on behalf of Minerals Separation Ltd.

I am, dear Sir,

Yours faithfully,

JOHN BALLOT,

For and on Behalf of Minerals Separation, Limited.

1140 COMPLAINANTS' EXHIBIT.

Hyde Acceptance, March 3, 1910.

Minerals Separation, Limited.

62 London Wall.

London, E. C., 3rd March, 1910.

John Ballot, Esq., Chairman of the Board of Directors, Minerals Separation, Ltd., 62 London Wall, London, E. C.

DEAR SIRS: I have received your letter of March 2nd, 1910, for which I thank you, and I hereby accept employment with the Minerals Separation Ltd. on the terms mentioned therein and in the cables between T. J. Hoover and J. M. Hyde dated January 18th, 20th, 21st and 24th, 1910.

I am, dear Sir,

Yours truly,

JAMES M. HYDE.

1141 COMPLAINANTS' EXHIBIT.

Nutter Report, July 28, 1910.

Minerals Separation, Limited,

62 London Wall, London, E. C.

Dictated to M. E. P. by E. H. N.
Enclosures 1.

To the Board of Directors, Minerals Separation, Ltd., 62 London Wall, E. C.

28th July, 1910.

DEAR SIRS: I hand you herewith a report on the costs of construction and operation of the Minerals Separation Plant at Broken Hill, N. S. W.

This is not a complete report, as certain phases of the same subject will be referred to in a later report.

I am dear Sirs,

Very truly yours,

(Sgd.) EDWARD H. NUTTER.

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A Report on the Costs of Construction and Operation of the Minerals Separation Plant at Broken Hills, N. S. W.

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1142 Recoveries.—We have seen how the bad design has affected construction and operation costs. We come now to the effect it has on recoveries. As stated elsewhere it is important to provide means for determining the actual rate of feed to a flotation plant at any instant. While I was in Broken Hill some daily records were kept in such a way as to show the relative efficiency of the different shift bosses. A record was kept of the tonnages treated, supplies used and concentrates produced on the different shifts. The day shift on May 27th produced 109 tons of concentrates from 293 tons tailings, using 168 lbs. of eucalyptus oil and 78 cwt. of acid. The afternoon shift got 99 tons from 294 tons of crudes, with 168 lbs. of oil and 99 cwt. of acid. The night shift got 81 tons from 255 tons of crudes with 182 lbs. eucalyptus and 91 cwt. acid. The day shift on June 2nd got 102 tons from 286 tons crudes, using 126 lbs. eucalyptus and 91 cwt. of acid. On the afternoon shift 110 tons of concentrates were produced from 277 tons crudes with 126 lbs. of oil and 59 cwt. of acid. On the night shift the results were 106 tons of concentrates from 280 tons of crudes with 126 pounds of oil and 75 cwt. of acid.

The comparative sheets show that the material treated during the

weeks in which these dates occur was practically the same in sizings and assays.

1143 Time.	Pounds concentrates per ton of crudes.	Concs. ratio.	Pounds acid per ton concs.	Pounds acid per ton crude.	Pounds oil per ton concs.	Pounds oil per ton crude.
May 27th.						
Day shift.....	833	2.678/1	90.19	29.82	1.541	0.574
Afternoon shift	754	2.97/1	112.00	37.72	1.697	0.572
Night shift....	712	3.15/1	132.7	42.15	2.248	.713
June 2nd.						
Day shift.....	799	2.80/1	99.9	35.64	1.235	0.441
Afternoon shift	890	2.55/1	60.1	23.85	1.145	0.455
Night shift....	848	2.64/1	79.3	30.00	1.188	0.450

These figures indicate a wide variation in results during the different parts of the same day. The figures are really incomplete without complete assays showing metallic and insoluble percentages for the same periods. The insoluble is not apt to vary greatly, however, so we can take the figures we have, as approximately indicative of the work done. The difference per ton on recoveries between the best and the poorest with the concentrate assumed to assay Ag 15 ozs. Pb. 9.4% and Zn. 47% in each case would amount to 4/10 per ton of crudes with zinc at £21. The difference between the same ones on costs of oil and acid used would amount to 7d. for acid, and 2d. for oil, making a total difference of 5/7 between the best and the poorest.

If we take, in the same way, the difference between the best results and the average we will get an indication of part of the constant loss due to poor regulation. This works out on recoveries to 2/3.6 per ton of crudes, and 4.3d. on oil and acid consumption, or say
1144 2/8 per ton of crudes.

It is a practical certainty that the best results shown in this comparison are below the best possible results obtainable by complete knowledge and exact regulation, for these are merely the results of more accurate guessing at the proper feed and regulation by one shift boss, compared with the others. We could only hope for him to get the best results occasionally, and by accident. It is a very safe assumption, then, to assume that exact knowledge of the rate of feed of all quantities, and the consequent exact control, make a difference, and has made a difference of at least 3/- per ton. We have then a further charge of about £90,000 in possible profits that can be charged to bad design.

The various items summarize as follows:

Unnecessary charges in the construction costs

Material	£4,139	
Labor	4,890	
	£9,029	
say	9,000 per ton on	600,000
Unnecessary working costs as a result of bad design or otherwise	1/0.34	£30,850
Loss in recoveries, due to bad design, say	2/3.9	£70,000

1145 COMPLAINANTS' EXHIBIT.

Nutter Report, December 3, 1910.

Minerals Separation, Limited.

62 London Wall, London, E. C.

Dictated to E. N. P. by E. H. N.
Enclosure 1.

3rd December, 1910.

The Board of Directors, Minerals Separation, Limited, 62 London Wall, E. C.

DEAR SIRS: I transmit herewith a paper entitled "Technical Development of Minerals Separation Process," which is the last of the Reports based on my trip to Broken Hill.

Very truly yours,

EDWARD H. NUTTER.

Technical Development of Minerals Separation Process.

It would be hardly accurate to refer to this paper as a report as it is almost necessarily an argumentative discussion embodying my personal views concerning the relative importance of the various unsolved problems, and the most promising lines of investigation leading to their solution.

1146 One of the most important group of problems is that concerned with the development of the best design of plant for carrying on the essential operations which go to make up the Minerals Separation flotation process. It is to be understood of course, that no design can be completely worked out in advance that will be suitable for all ores, or for any ore. The different parts of the general problem will have different weights in the different cases, and the relative importance of the different operations will hardly be the same at any two mines. In other words each ore presents a separate problem to us as well as others. It is safe to say that there have been more metallurgical failures as a result of lack of appreciation of this general truth, than could be traced to any other cause. It is important however to crystallize our knowledge into rules for

estimating the weights of the different variations to be met with as much as possible, so that we need take the minimum of time in working out a design to meet particular conditions. Thus, given a complete analysis of an ore and assays of the different sizes of a finely crushed sample of it, we should be able to tell approximately what we could do with it as soon as we get a few small scale results. Before the last word can be said as to what is the best standard design of a plant, a lot of experimental work will have to be done, and new apparatus designed or invented.

It is of course our object to find conditions under which all the possible ores can be worked. It is also our object to raise extractions to the highest practicable figure. We want to develop the
1147 process so that it will be a process of general application, in the treatment of base ores.

In many parts of the World there are ores of varying degrees of complexity in which the minerals are so intermixed as to interfere in the commercial extractions of each other, and the value of the ore is thus reduced far below what it might be if good separations could be made. To this type belong various lead zinc silver, lead zinc silver copper, and zinc copper ores. These comprise a large class among which are some highly important ore bodies. Portions of the Broken Hill ores, some of the Tasmanian ores, and some of the basic ores in North America are examples. The separation between the various sulphides present in such ores is a highly important problem then, if not the most important problem ahead of us.

A problem of about equal importance is the development of apparatus and process for the treatment of disseminated copper ores so that on at least the combined basis of recovery and cost we can compete directly with ordinary wet concentration machines and methods. If we can make a showing of increased net profit in the treatment of Ely, Nevada ores, and various of the Arizona and Montana ores, as compared with the wet tabling now in use and planned, we would tap an immediate source of large income. The exploitation of this business involves pressing the investigation of distillation products from wood, as wood tar oils will probably prove to
1148 be our most general frothing agents for copper ores.

Another highly important problem, but one necessarily forced into the back ground by the others, is the finding of a flotation treatment for oxide and carbonate ores. Connected with and forming really a part of the preceding problems is the development of treatment and apparatus for getting good commercial results in cold circuits, that is circuits at atmospheric temperatures.

Important parts of the preceding general problems are the design and choice of apparatus for feeding the various ingredients to a plant in the exact proportions required, and the performance of each necessary operation with maximum economy.

All of these require that any scheme of treatment devised shall give maximum recovery without the sacrifice of grade of product, and with the consumption of minimum amounts of reagents, and of fuel and power. In other words the controlling factors and conditions are always commercial ones and we must not lose sight of the fact that

our endeavours must be guided by commercial requirements. These requirements dictate that we must determine the limits of our various reagents, particularly the cheaper, most abundant and most widely distributed ones. When any particular ore comes in then, we should devote ourselves to finding out what results are obtainable with the reagents which commercial considerations will confine operations to.

1149 A corollary of this is to find the upper limits with each frothing agent which does not interfere with subsequent tabling and vanner work. This is particularly important in the case of petroleum..

Differential Separations.—By differential separations, I mean separations by flotation, either directly or indirectly, between two or more valuable minerals. The separation by differential flotation or flotation sizing, between blende and galena, in such ores as the Broken Hill ores in which both the blende and galena are flotable is an example. Along this line some promising partial results have been obtained.

For instance while I was in Broken Hill a number of samples were taken of the froth floating on top of the pulp in the various mixers in both plants. All of the series of samples taken showed a tendency on the part of the silver to float ahead of the lead and of the lead to float ahead of the zinc.

A series of samples taken from the mixers of the zinc section of the Sulphide Corporation Company's mill during the first week in May 1910 assayed as follows:

	Ag.	Pb.	Zn.
General assay for week.....	6.5	6.4	19.9
Mixer No. 1	30.4	33.4	29.0
" No. 2	26.0	29.2	30.6
" No. 3	17.2	16.0	42.2
" No. 4	11.6	10.8	44.2
" No. 5	14.6	12.9	42.2
" No. 6	13.4	11.1	44.0

1150 This was the best set of results obtained. In others the lead was lower in the first two mixers.

This tendency for different minerals to float differently has been noticed from time to time in experimental work on different ores, but so far the results have all been indeterminate.

It would appear that the hope of accomplishing a differential separation in one operation, or of finding a flotation reagent that would effect a direct and complete differentiation between different sulphides, has led experimental work away from the lines which appear to hold out most promise.

A differentiation such as that tabulated above lends itself to only a limited number of explanations. Either one mineral tends to float easier than another mineral, on account of intrinsic differences between the two, or else the apparent preferential effects noticed have been the result of differences in size and shape.

If the first is the correct explanation of the observed differentiation

and I think it is, it would be reasonable to assume that the action is as follows: With an air or gas saturated solution the points at which free gas first begins to form, are those points where the forces tending to hold the gas in the ionized state, are first overbalanced by the forces tending to pull the gas into the free state. Pointed solid particles have a decided influence on such phenomena, and this fact is made use of in every chemical laboratory to give quiet ebullition instead of bumping when solutions are being boiled.

1151 If there is a pointed object in the solution near the point of heat application, the steam bubbles form readily at the point and pass off quietly. If there is no such pointed object, and the interior of the glass vessel is very smooth and the solution is clean and free from particles, the steam forms intermittently and explosively, and the bumping is at times so violent as to break the containing vessel.

Now it would not seem unlikely that different sorts of points would have different powers in this regard, and if a "smooth round" point and a sharp ragged or rough point both of the same material were placed close together, ebullition would begin at one in preference to the other. It would also seem not unlikely that if two points, one say of galena and the other of glass, were placed close together, that ebullition would begin at one in preference to the other. In the same way, as between two galena points, one of which had been oiled or acid treated or both and the other had not, a preference might be shown. Likewise, as between two points of any differing material, such as galena and blende, or galena, blende and chalcopyrite, one of them would probably be preferred to the others. This suggests what might prove to be an important line of experiments. That is, a careful determination of the different temperatures at which ebullition begins by using points of different minerals. Should we find, for instance that when points of galena and blende were used, that ebullition always began first at the galena and at a lower tem-

1152 perature than at the blende, it would indicate that galena exerts a stronger pull on gases about to come out of solution than does blende. A determination of these temperatures for various conditions with different minerals will enable us to more intelligently control the operations of experimental plant runs. A start has been made on this line of experiments. One reasonable explanation then of the differential flotations we have observed would be that a preferential gassification does take place on the galena particles, as compared with the blende particles, and the tendency is therefore to float the galena particles first. The tendency is not sufficiently pronounced, however, to give sharp separations, at a single operation.

If this is the correct explanation, we can hope for differential flotation becoming a fact as the conditions surely ought to be found that will enable us to repeat the same operation on the preferentially formed concentrates, and get a richer and richer lead concentrate, say, on the one hand, and a richer and richer zinc concentrate as a residue, on the other hand by the removal of the galena, and all as a result of repeated fractionings.

Should this turn out to be the way of it, we will find probably, that

variations in the acid, in the oil and in the amount of aeration will all have their effect, and some combination of these will give us the conditions for maximum differential results between any two minerals, as for instance, blende and galena.

1153 If the hypothesis we have taken is not the correct one but instead, the differentiation is due to differences in the mechanical aspect of the particles, it would be reasonable to expect that something like this takes place. When the solution is at the gas saturation point and the condition of overbalance is reached so that ebullition begins, there would not be any preferential selection of points by the gas coming out of solution and we would have gas forming at all the points irrespective of the nature of the material forming the points. As the gas attaching to the particles accumulates into bubbles, the smallest particles should be the first ones to float. If the action were stopped here, we would expect the finest sulphides to be floated first, irrespective of what the mineral happened to be. As a matter of fact our whole process is based on the selective tendency metallic sulphides have for floating under conditions that will not float gangue minerals. The idea that all sulphides have equal tendencies to float is logically untenable, and directly against our whole experience.

There is no sharp, clean cut separation between different sulphides, however, except when carefully sized. Hence, probably, the limits are narrow within which we can get clean results, and so far we have not succeeded in confining our test conditions to those limits.

Henry Lavers, I understand, has obtained clean separations by flotation between different sulphides after previously sizing the material but this can of course be obtained otherwise on such material.

1154 This result, however, is exceedingly valuable as furnishing sound footing for our deductions, that there is an intrinsic difference in the tendency of different sulphides to float under the same conditions; and that repeated fractionings should yield commercial separations; and that flotation sizing is an inherent tendency and not an accidental effect under certain sets of conditions.

My own opinion of the relative commercial importance of the different tendencies enumerated is to give flotation sizing first place. It is a new classification tool and should enable us to sort out the particles in a finely crushed complex ore into certain classes depending on a different set of physical properties than any hitherto used in this connection.

If we then take these classes of particles, and subject each class separately to a different set of conditions from the first, such as obtain on a vanner or Wilfley we should have each class further split up into smaller groups as a result of intrinsic differences in other physical properties than those first made use of. I look upon this as the quickest route to a differential separation of complex sulphides. I am confident that we could design a plant from data already in our possession that would work and give commercial separations on ores of good grade not too finely crystallized that are amenable to flotation.

Thus, take the case of separations between chalcopyrite and blende, one of the most important to make, from a commercial standpoint on

account of their frequent occurrence together in important ore bodies, and their mutual interference in smelting. This sep-
1155 aration is one of the most difficult to make in ordinary wet mills on account of these minerals having so nearly the same specific gravity. In flotation work we have found that zinc blende is very difficult to float in a non-acid circuit, while chalcopyrite floats extremely well in a non-acid circuit. The immediate inference from this is that here is the treatment we want. Remove the copper in a non-acid circuit; and then get the zinc after the copper is recovered. Work along this line however has gone to show that one of the few conditions under which we can float zinc blende in a non-acid circuit is when it is accompanied by chalcopyrite. So far as we have observed, the flotation is not clean of either mineral as we get a good deal of zinc in the non-acid froth and have some unfloated copper in the tailings. An examination of the products showed, however, that the blende particles that floated were the very fine particles only, while practically all of the chalcopyrite except the coarsest was floated. We have then in non-acid work on such ores, the copper tending to bring up the zinc, and the zinc tending to pull down the copper.

If this material were sized into say six sizes, numbered 1, 2, 3, 4, 5 and 6 of which number 1 was the largest, we would probably have in a froth produced without acid, some of the number 1 copper, most of the number 2, and practically all of the 3, 4, 5 and 6, and this would comprise the bulk of the copper in the ore. We would also probably have some of the Number 6 blende and perhaps a
1156 little of the number 5. In the unfloated portion we would have the 1, 2, 3, 4 and some of the 5 and 6 blende, together with some of the numbers 1 and 2 copper. If this froth should be tabled or vanned, and also the residues, we should get fairly clean copper concentrates, and fairly clean zinc concentrates. We should get also a coarse middling, and a slimy tailing, consisting probably of unsaleable mixtures of the two sulphides. The commercial efficiency of such an application of the process to any particular ore, would depend on the ratio between the saleable and unsaleable products. If the amount of middlings was too great, we would have three courses open. One, the taking off of partial products in the first instance, and tabling these separately. Should this leave too much coarse mineral in the coarse tailings as a result of robbing the pulp of the fine sulphides at an early stage, we could instead take all the sulphides off, leaving a clean tailing, and then retreat the concentrate, dividing it into partial products which could be tabled separately or not, as desired. An alternative scheme to this would be to fix the conditions of the first flotation so that a maximum of copper would come off with as little zinc as possible. A retreatment of this product by flotation could be expected to give a fairly clean copper concentrate and a zinc reject containing some copper which could go back to the first set of mixers.

These are of course, merely suggested lines of treatment, but I am fairly confident that with such an ore, assuming that the sul-
1157 phides will float, that a method of treatment involving flotation, and tabling or vanning could be worked out which would yield commercial products.

The same would in general be true of other sulphide ores such as lead, zinc or lead, zinc copper, but a simple copper zinc ore would probably be the easiest to work and offer the simplest problems. Theorizing is of course futile, unless supplemented by experimental results, but it is essential that experimental work be guided by theoretical considerations.

A little thought will show that as we deal with finer and finer particles, in which the ratio of mass to superficial area approaches infinity, that the limits of variations in differential treatment approach closer together, until with exceedingly fine particles no differential results would be obtainable.

For instance, in the case of a very fine lead zinc slime, such as that produced at Broken Hill, we would have sulphide particles which settle in water with a great deal of difficulty and slowness. It does not require much imagination to see that with such particles any condition which resulted in any tendency at all for the particles to float, even though it might be much stronger for the galena than for the blende would bring both the blende and galena to the surface together and we could effect no differential separation between them.

On material coarser than these particles, however, I think we have a right to expect that separations can be made by a combina-
1158 tion of partial products flotation with tabling and vanning of the separate products.

Careful regrinding by stages in short tube mills, to avoid excessive sliming, and regrinding of the separated coarser particles, so as to reduce the sulphides to minus about 15 mm. screen, without the formation of much absolute slime, should quite completely separate the blende particles from the galena particles. Then, if such material were subjected to a partial products flotation, and the partial products were then tabled or vanned very clean separations between the lead and the zinc should result. From the work done at the Zinc Corporation, I would not be surprised if zinc concentrates running under 1% of lead could be obtained in this way and correspondingly clean lead concentrates.

Such a procedure would of course involve the rejection of some unvannable slime, such as the Zinc Corporation has been rejecting, if we are to get such a clean zinc concentrate. We would remove as a lead concentrate, most of the lead that now goes to bring the lead content of the zinc concentrate up to the smelter minimum, and sell it as a lead concentrate, we could then mix in with the high zinc concentrate enough concentrate slime to bring the lead up to the required amount, and ship the mixture as a zinc concentrate. We would thus trade off the, at present, worthless lead in the unvannable slime for a good lead concentrate; and we would also get paid for the, at present, worthless zinc in the unvannable slime.

Let us take an example. Broken Hill Blende, when pure,
1159 carries about 55% of zinc. A zinc concentrate then, containing 2% insolubles and 1% of lead would assay 1% Pb. 53.24 Zn. and say 8 ozs. Ag. per ton. If we assume that the unvannable slime sulphide assays 20 ozs. Ag., 20% Pb. and 35% Zn. and that the zinc concentrates will be fined by the smelters if running

under 7% of lead, we would have in a combined concentrate mixed so as to meet this requirement the following assays—Ag. 11.8 ozs. per ton, Pb. 7%, Zn. 47.5%. This mixture would be worth £2. 18. 0. net per ton with zinc at £22.

If we started with 100 tons of concentrate assaying Pb. 7%, Zinc 47.63%, Silver 9.37 ozs. and 5% insolubles we would get on these assumptions 9.42 tons of lead concentrate worth £6. 6. 0. net per ton at Broken Hill and 87.69 tons of high-zinc, low-lead zinc concentrate. This last material would not be accepted by the smelters, but would have to be brought up to 7% lead again by mixing with it, high-lead, slime concentrate. The amount needed would be 40.47 tons of the assumed value. The resulting mixture would assay lead 7%, zinc 47.48% and silver 11.8 ozs. and would be worth net £2. 18. 4. per ton at Broken Hill. By this procedure then we would take 100 tons of zinc concentrate worth £2. 16. 6. per ton, abstract 9.42 tons of lead concentrate worth £6. 6. 0. per ton, and mix in 40.47 tons of present valueless slime concentrate, and get 128.16 tons of zinc concentrate mixture worth £2. 18. 4. per ton. There would be a total net
1160 increase in value of products of £150. 8. 7. The cost of the operations would be about £61. 9. 0. leaving a net profit of say £89. Looking at it from one point of view, we would be losing nothing on the saleable zinc concentrate, and would be working off material at a net profit of about £2. 4. 0 per ton, which is at present unsaleable. I have assumed highly efficient deleading, and I believe that highly efficient deleading would be obtained with the treatment indicated. The Zinc Corporation with ordinary water classification and tabling, deleads to below 5%. With stage grinding, partial products flotation and tabling I know that we can greatly better their results. To the extent that we do better their results, and delead below the smelter minimum, we can utilize the unvannable slimes, and on each ton of concentrates from these slimes so utilised we would make approximately the profit indicated. As we can partially delead any of the Broken Hill slimes, the slimes added should be mixed into the feed into the partial products plant. By doing this I would think that we should be able to utilise the slime concentrate at least in the proportions used in these calculations.

This scheme or method of treatment should enable the Broken Hill Mines to treat their current slimes at a profit and work off the accumulations from past work.

For the present, of course, such a suggested scheme has no application to the calcareous slimes at the North and South Mines, but it would be of a great deal of importance to the other mines as there is a possible two or three million pounds sterling profit in the
1161 silicious slimes stacked and to be produced if efficient deleading of all the granular materials is attainable.

In addition to the Broken Hill ores there are the large bodies of high grade Tasmanian ores, which should be amenable to the same treatment, if it works at Broken Hill. From the standpoint of the amount and grade of material awaiting treatment along such lines there is no more important problem in ore dressing or metallurgy awaiting solution; and any promising line for investigation such as

this, should not be neglected. I propose this, then, as a possible solution of the Broken Hill slime problem, and recommend it to your thoughtful attention.

Non Acid Process.—The development of a non acid process has reached the point where we can say with some confidence that it applies to a number of copper sulphide ores; and we have at our command a number of commercially available reagents that can be used on non-acid work, such as certain of the eucalyptus oils, turpentine, the cresol group of coal tar derivatives, wood tar oil and Stockholm tar. These yield good froths giving good extractions of copper in certain ores.

Calcite ores in which pyrite, chalcopyrite, zinc blende and galena occur, still remain a problem until we get reagents or manipulation that gives a flotation with little or no acid, with lead as well as copper.

Experimentation along this line will naturally consist of trying all the new reagents we find, on mixed ores, without using acid.

1162 Another rather suggestive line of research is that of treating frothing agents with small amounts of froth deterrents with the idea of rendering the oil selective for particular sulphides only.

This whole field seems a fertile one for experimental work, and with large possibilities for new and effective frothing agents being discovered, among the products from the destructive distillation of wood, it is a most hopeful outlook.

Cold Circuit Work.—An important commercial problem is the determination of the best conditions and the best form of apparatus for obtaining a good froth in a circuit at atmospheric temperatures only, on lead-zinc ores. If in connection with this, it should be found that petroleum or its derivatives could be used for Minerals Separation work many ores could be treated at a lower cost than at present. The saving would lie in the use of a cheaper oil, less acid consumption and no expense for heating circuit liquors. This might be termed an alternative scheme for use in some special cases, and for application to a wider range of ores, failing the development of a non-acid or differential process. Acid tar, a stage product of oil refining is of promise in this connection, as it gave a good appearing froth in the cold on Broken Hill tailings the first time we tried it. We know that cold circuit filming is feasible, and is producing heavy tonnages of concentrates. But it is not a slime process. We know also that the Elmore machines were not there, and that the froth were

1163 it is my idea that if the restricted discharge opening in the Elmore machines were not there, and that the froth were formed on a broad surface as in the Minerals Separation and Potter processes that the froth would, to a considerable extent, break down to a skin float or film. Should this be so, the reason the Elmore machine is a frothing machine is largely because it delivers the froth away from the machine before the bubbles have time to break and drop their load. It seems to me then that the development of a cold circuit process aside from the finding of some reagent that does the work at once, is going to be a matter of mechanics, that is, the development of an efficient form of bubble trapping apparatus. This as we know, is entirely feasible, and it only remains to build a set of

mixers and separating compartments based on the results we got with the modified Charlotte Street mixers and the ideas developed therefrom to have an experimental set of wide and various application, for the determination of many of our unknown factors. With this machine, we can take off two products from the mineral floated from each mixer, and these products in general will differ from each other in size of particles, or flotative tendency, or both.

Part of the material we would take off would be in the form of clean concentrates and part as dirty concentrates, which would need retreatment. In differential work all of the products would probably be retreated separately.

1164 There are a number of sound reasons for the belief that a combination of partial products flotation and retreatment of the separate products by ordinary concentrators would be the easiest and quickest way to a solution of the problem of separating the minerals in complex ores.

It enables us to make use of a larger number of physical properties in separating the minerals from each other than would water classification and concentration alone or any scheme of differential flotation alone. It follows unquestionably that a combination of the two methods of effecting separations between minerals, gives greater power over a complex ore than either one can alone. In other words, it enables us to make a sorting of the ore particles on the basis of one set of physical characteristics, and then take these different groups separately and resort them on the basis of another set of physical characteristics. We know that we can make partial separations by means of differential flotation. We know also that we can make partial separations of another kind by means of tables and vanners. It is reasonable to believe then, that a combination of the two methods will give us more complete separations, than either method can give us alone.

1165 While in many cases it may be found better work above atmospheric temperatures the cold circuit should be found useful in such ores as make for high acid consumption. The criterion in all cases will of course be the balance between increased extractions on the one hand, and increased costs on the other. It seems probable that one retreatment of dirty concentrates would be sufficient to eliminate practically all the contained gangue as 15% insoluble could be reduced to about 1% aside from chats, at a single retreatment.

It would seem almost obvious that we would be able to carry the separation as far or farther with a combination of easy applications of the two methods rather than with an extreme application of either one.

It should be mentioned in passing that the carbonate and oxide ores offer a practically untrodden field for investigation and when some of the more important lines of investigation have been worked down to the smaller refinements, experimental work on such ores should be undertaken seriously, as there is certainly a great need for an effective process to recover the values from such ores.

Design of Plant.—The material coming for treatment to a Min-

erals Separation plant will have originated in one of three ways. First, it will be finely ground crude ore, of which the preliminary treatment has been for the purpose of preparing it for Minerals Separation treatment. Second, it will be finely ground ore, which has already been subjected to treatment for the recovery of one or more minerals, and is sent on to the Minerals Separation process for further treatment. Third, it will be tailings which has resulted from milling operations in the past and been stacked; and has to be excavated, transported to the plant prepared for treatment, and treated.

1166 Of these three cases the most general is the second one, although the third involves operations that the other two do not.

Under the first case, would probably come most of the simple copper ores. The object would be to concentrate the copper mineral directly out of the ore without the use of any tables or vanners. In this class are many of the most important copper deposits. A treatment plant for such ores would consist of rock breaking, crushing and grinding machinery, in which no special care need be taken to avoid the making of slimes, as is now necessary. This would reduce the cost of preparation of material from the present figure, and be an item in favour of the Minerals Separation treatment. After simplifying the crushing we could eliminate the classification which is a large item in the capital outlay for a copper concentrator, and is usually an indirect item in the cost of operation on account of extra pumping.

This brings us to the concentration itself, and any comparison between Minerals Separation and ordinary wet methods must consider both cost of operation and recovery.

Practically the only data we have as to the cost of tabling and vanning in these large plants are the costs in the Boston Consolidated mill on Bingham Utah ores. The tabling, vanning and classifying in the Boston Mill cost 7.3 cents per ton of ore. On such ores as we find are amenable to Minerals Separation concentration, it is safe, I think, to assume that the cost of power and labour for

1167 Minerals Separation work would not exceed 2 cents per ton.

The cost of reagents is difficult to estimate without knowing what reagents would be used or the quantities in which they would be used. From our experimental work, however, it would probably be safe to take the minimum cost for reagents on such copper ores at not less than 2 cents a ton, and the maximum at not over 15 cents a ton.

On any ore then, on which we can give a substantial increase of extraction we can compete directly with ordinary wet concentration.

I think that any plant erected for the treatment of such disseminated copper ores will have to consist of mixers and spitzkasten, for taking off the concentrates, followed by mixers and traps for sweeping up all possible remaining values from the ore. The traps would probably deliver this product to regrinding apparatus, which would in turn deliver to the head mixer again. The concentrates from the spitzkasten would probably be delivered direct to retreatment mixers

where more water would be added and a clean low silica concentrate taken off. The tailings from the retreatment mixers and spitzkasten would go to regrinding apparatus, or to the head mixer again, depending on the nature of the material.

A plant providing all of these operations is quite easy of design and would be a single self-contained unit.

In the treatment by Minerals Separation of tailings coming continuously from an ordinary wet mill we would, I think, find
1168 that for the best work, careful regulation of the feed of ore from the bins, prior to any treatment at all, would be of considerable importance. If the feed is not regulated at the very start, it will be necessary later on to spend money to straighten out the kinks in order to avoid losses as a result of irregular working conditions. It may be that the importance of this provision will be minimized by the use of trap separators and retreatment, and I am quite sure that it will be at least reduced.

There is no doubt but that various devices could be designed and arranged for automatically regulating the feed according to the weight, but I am not convinced of the usefulness of such automatic regulation unless perhaps for special cases. It is essential in all cases to have arrangements to enable the rates of feeding oil and acid to be brought easily into exact concordance with the requirements of the ore. I am inclined to believe that this requirement would be satisfied within practical limits, by arrangements which could enable the foreman or plant manager to vary his rates of feed of ore, acid, oil and water, and determine what these rates of feed are at any given instant. If a plant is handled with intelligence, such information should be ample for the foreman and superintendents to control the operations easily and exactly. If the plant is not handled with the intelligence that would make such arrangements suffice, I doubt if further refinements would help matters much, as automatic controlling devices would require a high
1169 grade of intelligent care to keep them in proper working order.

Next in importance to a means for determining the rate of feed, at this stage of the operations, comes the sampling. This should be adequately provided for, or much of the advantage gained by controlling the feed will be lost.

The best sampling arrangement is something of a special problem in each case depending on the particular conditions prevailing at each property. At the Central Mine, where the ore is transported by aerial rope tram from the crusher bins to the mill, the first cut is taken by dumping every tenth bucket into a special sample bin. This sample is then worked down and recrushed until a convenient size for sending to the assay office is obtained. At the South Mine, the sampling mill is at the junction between the two elevating conveyors. It takes a definite cut of the ore, samples it down, crushes it and resamples it in Vezon samplers. The Central Mine arrangement is fairly good, but the South Mine arrangement is excellent.

In a mill designed for taking out certain products prior to the Minerals Separation process, such, for example, as the removal of

lead by jigs and tables in the lead mill at the Central Mine, the tailings from these operations will almost certainly require dewatering before they are fit for Minerals Separation work. This is particularly necessary for lead-zinc ores, as the Minerals Separa-
1170 tion process works best on such ores in a closed solution circuit, and the savings in oil and heat, and the increased recovery, are great enough to pay for the extra cost involved.

At the Central Mine a very crude and costly arrangement is used for dewatering. The combined tailings from the tables, vanners and annex are run on to thickening or drainage belts. These belts are nothing but wide, deeply troughed, slow moving conveyor belts, which continuously deliver at the discharge end the sands that settle to the belt surface. The water and slimes overflow at the sides. This water of course carries with the slimes a large proportion of fine sand. The coarse sands are delivered directly to incline conveyor belts which deliver to the zinc flotation plant. The fine sand and slime is carried by launders to a series of eight setting vats through which it passes in series. From the last vat the slime overflow goes to settling ponds. One settling vat is usually out of commission at a time, being emptied. This is done by working the sands through a hole in the middle of the bottom on to a conveyor belt which transports the fine sands back and delivers them in with the coarse sands. The slime overflow from these settling vats goes to large shallow concrete basins or paddocks. The slime flows in at one corner, and the water is pumped off at the diagonal corner, until the basin has become so full that the water comes off too dirty for mill purposes. The flow is then turned into another pond and the first one allowed to stand and settle. The supernatant water is pumped off,
1171 and the mud is spooned into small ore trucks by hand, hauled by horses to a platform alongside the return elevator, and dumped. The mud is then shovelled by a crew of men on to a conveyor, whence it joins the sands on the way to the zinc section.

This man-handling costs about 2/- per ton of slimes or 6d. per ton of crudes and is a crude arrangement. The obvious thing to do at this point is to filter the combined sands and slimes. It is an open question, however, as to which type of filter is the best. The Wilfley or Oliver drum filter is more applicable to this particular problem probably than is a filter press or a vacuum filter of the Moore or Butters type. The drum filters, though, do not seem particularly well adapted to filtering a pump mixture carrying much heavy sand; and I am of the opinion that a horizontal annular ring filter offers promise of a wider application to such dewatering problems than any other type.

Since the above was written I have been informed that the Wilfley filter has been tried recently at the Central Mine and found unsuitable.

There are, of course, certain slimes that filter with great difficulty, and these can only be handled by filtering plants of the Moore or Butters types, that have great areas of filtering surface. I would not expect the Minerals Separation process to have much application to ores of this extremely slimy character however.

Any estimates of the cost of filtering are of course unreliable
1172 unless they are based on tests on the ore to be filtered, but from what I have seen of the Central Mine ore, it seems to me that 2d. per ton should be a sufficient allowance for dewatering the pulp between the lead mill and zinc mill. As the crude, sloppy and unscientific method they pursue now costs 6d. per ton of ore, a filtering plant would pay for itself quickly and be in every way better. The Central Mine management appears to be alive to this fact.

The Central Mine operations illustrate the point, however, that some sort of dewatering arrangements will have to be provided for, ahead of the Minerals Separation plant, where it is installed as an adjunct to an ordinary wet concentration mill. The necessity for filtering or dewatering will be much lessened if we find we can do successful cold circuit work.

In the continuous treatment of an ore such as Central Mine ore, while it is important to regulate the tonnage going to the Lead Mill, and know the rate of feed, it is more important to know the rate of feed to the Zinc section, so that the oil and acid can be regulated exactly. A continuous conveyor weigher would probably be the best working device, if room enough in the conveyor belts was available. Failing this, a pan to swing under the feed and catch it for a definite interval, would be simpler, and the next best arrangement. I have already shown in a previous report, how greatly the recoveries are affected by variations in the rate of addition of oil and acid.

As a matter of fact, the introduction of means for regulating
1173 the feed and for determining its rate, are chiefly for the purpose of providing data from which the oil and acid feed can be determined. We will assume then that we know the rate of feed of material to the mixers, and from experimental work, the proper quantities per ton of oil and acid to give the best results. These reagents are to be fed steadily at the determined rates. If it should be desired to change the rate, this should be done easily and certainly.

There are three different general ways to control the feed of oil and acid. One is to feed a definite weighed quantity, at prescribed intervals. Another is to feed a definite measured volume at prescribed intervals, and a third is to have a definite even flow of material, which will, of course, deliver a definite weight and volume in a prescribed time interval.

The first method, that of weighing out quantities of oil and acid and adding them at stated intervals, seems impracticable, and I am unable to conceive a form of apparatus, worth a second thought, for doing this. The third method, that of adding the oil and acid in an evenly flowing stream of definite rate, would seem at first glance an easy and practicable means of adding these reagents at the proper and desired rate. There are practical difficulties in the way of doing this, however, and I have been driven to the conclusion that other means would prove better.

With any liquid the flow through a given orifice varies as the

square root of the height of liquid above the orifice. The general expression for the law is $V = e\sqrt{2gh}$.

1174 If e could be taken as constant for any given material through any given orifice, and the volume of it determined experimentally, our problem would be easy. Unfortunately e is a quantity which varies with the viscosity of the material flowing through the orifice; and with most of the oils of importance to us, the viscosity varies widely with the temperature. In order then to use a feeding device based on this principle, the temperature would have to be maintained constant. This, of course, can be done, but it involves additional care and expense. Another practical difficulty, too, would be, in the case of oleic acid, the uneven texture of the material. Unless it is kept quite hot, films and lumps form which plug up a small orifice. This caused a good deal of inconvenience in the trials at the Zinc Corporation, and vitiated some of the results.

In ordinary crude commercial sulphuric acid there are usually flakes of sulphate, and other foreign particles which have to be guarded against, as they could easily give trouble in a small orifice.

It would seem, then, that some positive feeding device would be better if a simple and effective one could be built.

A various assortment of devices could be made to fulfill this purpose, but the one that seems to me to offer the most promise for satisfactory working and maintenance is some modification of a plunger pump. This is a positive feed engine-lubricator built at Rochester, New York, that comes pretty close to the mark we are aim-

1175 ing at except that as at present built and marketed, it is not exactly suitable. In the mechanical essentials, however, it is what we want. I have been in correspondence with the London Agents to see if the Company would build the lubricators modified to meet our requirements. The matter was taken up with the manufacturers in Rochester, but they have expressed a disinclination to bother with the business. We will probably have to design and build our own apparatus of this sort.

Dry Tailings.—The preparation and feed of dry tailings has been worked out in different ways at Broken Hill, notably at the Minerals Separation plant, the Zinc Corporation, the Proprietary and the de Bavay plant.

The operations to be performed in each instance are:

a. The excavation of material.
b. The transportation of material to the plant and delivery to the ore bins.
c. The feed of material to the regrinding section, if such is required.
e. Regrinding.
f. The preparation of the reground material for the mixers.
g. Delivery to the mixers.

a. The Excavation of Stacked Tailings.—There are two general methods of doing this. One is by hand, and the other by machinery. In general, it can be said that excavation by machinery is performed

with maximum economy, when the excavator is running full
1176 capacity and full time. The crew per shift is approximately the same for any reasonable tonnage. In the case of steam shovels, of course, an average of more track layers, and men in train crews is necessary when large tonnages are being handled than with small tonnages, but such charges would be very nearly constant tonnage charges, increasing slightly per ton, however, as the tonnage handled was reduced.

A steam shovel can be worked with fair economy when it can be kept going steadily for a full shift. In the case of excavating a tailings heap by steam shovel, the amortization charges would be spread over the whole tonnage, which is a definite amount, whether that tonnage were excavated in two years or ten years. The tonnage charges for amortization would be increased somewhat in the case of a longer period, by the interest charges on the unredeemed amount. An example will make this clearer.

Assume 1,000,000 tons.

At 850 tons per day for 300 working days this will last say 4 years. If we assume our excavating plant costs £2,000, and if we amortize at 5% we will have to charge £564 each year against the tonnage to take care of our interest. This is .54d per ton.

At 333 tons per day the dump would last 10 years, and we would have to charge out £259 per year for amortization or .62d per ton. These are, of course, insignificant amounts, but they serve to illustrate the statement. If the tonnages available and required
1177 are not such as to permit of a full shift's work each day with the machine, economy falls off rapidly.

At the B. H. Proprietary plant an average of between four and five men per shift are required for operating the steam shovel and attending to the track. Besides these, three or four men are required for looking after the conveyors, etc. They thus require nearly the same number of men per shift to excavate the Proprietary Co.'s tailings by steam shovel, as is necessary to excavate the tailings for the Minerals Separation Company by hand and get them to the bins. As mechanics are paid a higher rate than shovellers, and as a steam shovel requires coal, oil, water and repairs besides the labor of operating, it is quite plain that hand shovelling is the cheapest method up to very considerable tonnages. In general, then, we can conclude that in practically all cases hand shovelling will be the cheapest. I do not know of any other very large tailings heaps, like the heaps at Broken Hill, that we are apt to find important to us. In cases where there are less than a million tons, it is not worth while figuring on a steam shovel. I can conceive of mechanical appliances being developed along other than steam shovel lines, in such a way as to make it profitable to mechanically excavate smaller dumps than can now be handled, but that is another matter.

The best method of transporting tailings from the pile to the treatment works will have to be worked out in each individual case. Depending on the location of the treatment plant with refer-
1178 ence to the dumps, different means of transport will work out as the cheapest for different locations of plant. Thus,

the Zinc Corporation has found, that, for certain dumps the most economical method is to shovel into ordinary mine cars and dump these into railway trucks, in which the sands are transported to the plant. For treating the South Mine tailings, however, they have built an aerial wire rope tramway, as the situation of the dump relative to the works is such, that such a tramway works out as being the cheapest means of transportation. On the other hand, the transportation by the small cars into which the tailings are shovelled, from the dump to the bins, is unquestionably the cheapest way of getting the Minerals Separation tailings to the plant. The Proprietary has worked out a system of belt conveyors and bucket elevators as being the best for their needs, and, for the tonnages they handle, I presume it is.

We cannot then choose any particular system of transportation as being the best for all cases, for it will not be. Each individual case will furnish its own variation of the problem, and will have to be worked out separately. Neither could we usefully discuss the characteristics of the different methods, for the weight to be given to the different variations will be different for the different cases.

Ore Bins.—The factors controlling the design of ore bins are the cost of erection, and the cost of operation as it may be affected by the design. In cases where the mill site is on a good sidehill
1179 location, there will not be much chance for variation of the bin design. Where a treatment work is being erected on a flat, however, a number of variations are possible, and these work out as follows: Of the various possible types of ore bins, a bottomless bin in which the ore would be filled in directly on the ground would require the least timber for construction. This sort of a bin would consist merely of four walls, properly tied together with rods. One having a total capacity of 500 tons, with a run out capacity of 175 tons, at a point conveniently high for the ore feeders, or say five feet above the ground, would require 12,000 super feet of Oregon timber and lumber for its construction, on the basis of a safety factor of 6.

If instead of building a bottomless bin we would build one with a flat bottom at the point we have located the feeders, or five feet above the ground, we would need, using the same safety factor, about 15,000 super feet of lumber. This bin would have a total capacity of 385 tons and a run out capacity of 175 tons. If instead of a flat bottom we have a bottom sloping 45°, and the feeders at the same point, we would have a total and run out capacity of 180 tons, and 13,000 super feet would build the bin. A flat bottom bin of the same capacity as before, elevated 20 feet above the ground on posts, would require 24,300 super feet to build it. A sloping bottom bin for 175 tons capacity at the same height, would require 19,500 super feet.

Ore Feeding Devices.—There are a number of different ways in which dry tailings can be fed out of an ore bin, and several
1180 of the devices manufactured are capable of a wide variation of adjustment and are good dependable machines. If means are taken for eliminating stones, rubbish and pieces of iron from the tailings, the Challenge Feeder is about the neatest and most

ecective of the various devices on the market for regulating and controlling the feed of crushed ore and tailings.

For feeding tailings that have not had metal and trash removed, the Push feeder as used at the Minerals Separation plant and at the Proprietary is a good device, except that the punched plate in each feeder is not a good substitute for an independent screen taking the whole feed. When a plant is working on dry tailings a good regulation of the feed is easier to get than it is when the flotation section is working on current tailings from previous treatment.

For a large plant we might have Challenge feeders delivering tailings to a conveyor belt running in front of the bins. The conveyor belt would be equipped with a continuous weigh bridge and would deliver to the grinding section. For smaller plants, Challenge feeders in front of which pans on spring balances could be swung for weighing portions of the feed at definite intervals, would be a good arrangement.

In ordinary cases tailings would have to be reground for Minerals Separation work and a comparison of different forms of regrinding apparatus is useful. The determining factors in such a comparison
1181 are the efficiency of regrinding and the cost of regrinding. In a large sense the latter includes the former. The following comparison will be restricted to two types of apparatus, the pan and the tube mill.

I have no comparative data bearing on the value of the Chile Mill as a regrinding machine for our purposes. On account of the growing scarcity of flints for tube mill work, however, the Chile Mill will become of larger relative importance in the future.

Pan grinding in Broken Hill has four different variations. There is positive grinding with 5 foot diameter, and with 8 foot diameter pans, and classifying grinding with the same sizes. By positive grinding is meant feeding the pans in such a way that the only escape for the material is between the grinding surfaces. In the pans which are usually used for grinding the oversize from the screens, the discharge of the pan is set higher than the discharge from the grinding surfaces. This keeps a considerable body of pulp in the pan and results in a classification of the material before discharge, much of the coarse staying in until it is reground.

At the Minerals Separation plant there are twelve 8 foot diameter pans. As between these and the 5 foot diameter for efficiency, we have practically a direct comparison with the Zinc Corporation work. The grinding at the Zinc Corporation is a little coarser, hence, with equal, or lower costs at the Minerals Separation, the comparison would be in favour of the 8 foot pan as against the 5 foot.

From the reports of the Sulphide Corporation the total cost
1182 of regrinding for the last half of 1909 with 8 foot pans was 13.836d. per ton in the Minerals Separation plant and 13.452d. per ton in the Lead Mill. In January, 1910, a normal month, the cost of regrinding at the Zinc Corporation with 5 foot pans was 17.54d. per ton. At the South Mine the cost of regrinding with 5 foot pans for the last half of 1908 was 17.1d. per ton. The Broken

Hill Proprietary furnished me with their costs of pan grinding with the 5 foot machines, and their figures total 24.87d. per ton.

Of course none of the pans were working on identical material nor were they working under exactly parallel conditions, nor is it likely that the costs were arrived at in the same way, but in spite of all these possibilities for discordance in the comparisons, there is enough margin between the costs we have, to indicate quite definitely that the larger pan does the cheaper grinding. This is an item to the credit of the management of the Sulphide Corporation, for having adopted the larger pan.

At the South Mine, the cost per ton of regrinding with a 4½x13 foot Krupp tube mill for the last half of 1908 was 9.02d. per ton, as compared with 17.1d. per ton for 5 foot pans on the same material. At the Broken Hill Proprietary the cost of regrinding with a 10′x5′ tube mill was given me as 11.15d. per ton, compared with 24.87d. per ton for 5 foot pans on the same material. At the North Mine it was stated to me that the 5′x10′ tube mills took about three quarters of the power required by the pans, for the same tonnage, and did better work.

1183 To my mind there is no doubt but that the tube mill is less sensitive to fluctuations in feed, is more easily kept in adjustment, is more dependable, and more nearly fool proof. On the basis of my own experience alone, with pans and tubes, I would have very little hesitation about installing tubes, for practically all fine grinding work. The sliming done, depends on the length of time the material stays in the tube, which is a function of the length of the tube and of the rate of flow of pulp through the tube. At Broken Hill it has been found that the 10′x5′ tube turns out the best work when it has a rather dilute feed. Under these conditions, it makes about the same proportion of slimes as the pans, is easier to regulate, and cheaper to instal, for the same tonnage capacity.

Tabulated Comparison.

Charge.	M. S. 8 ft. pans.	S. C. 8 ft. pans.	Z. C. 5 ft. pans.	S. M. 5 ft. pans.	Prop. 5 ft. pans.
Labour & salaries.....	2.772d.	1.812	2.69	.9	.90
General Supplies.....	.84	....	3.97	.1	12.70
Water	.372	.252	1.11		
Power	5.928	6.444	6.17	11.0	7.50
Rep. & main.....	3.528	4.704	3.35	5.1	3.77
Samp. & Assay.....	....	....	.23		
Sundries	.384	.216	.02		
Total cost per ton..	1/1.836	1/1.452	1/5.54	1/5.1	2/0.87

1184 I think it can be assumed, then, that for fine grinding the tube mill is for most cases the better and more economical of the two devices. This would not be true of course in cases where the tube mill could not be run at its full grinding capacity. After re-

grinding, the pulp can be screened or classified, and of these, screening is technically the best. As commercial screening of large tonnages is done wet at Broken Hill with the local variations of the King screen of sizes down to .25 mm. corresponding to ordinary 50 mesh cloth, such screening does not offer the difficulties it did a few years ago. From this point onward, the treatment would be much the same in all the cases depending on the vagaries of particular ores.

We come now to the question of actual treatment and what is the best form of agitator, mixer, separating box, etc., to use.

The answer to this question varies with the terms of the problem. The terms of the problem are controlled by the nature and characteristics of the ore and the results aimed at. Thus if we have a heavy sulphide ore containing several different minerals which have to be separated from each other, before their full value can be realised, our investigation and testing will naturally follow a different procedure, than it will in the case of an ore containing a relatively small amount of a single valuable mineral. We are always aiming at a maximum extraction of £. s. d. from the ore. In one case this may mean a maximum extraction of the valuable mineral; in another a lower extraction of the mineral with a higher grade
1185 of product; in another, a good extraction of one mineral, at the expense of a poor extraction of another, and so on. In other words, the commercial requirements are always the dominant factors.

Several types of plants have been designed for the treatment of ores by Minerals Separation process. Of these the type that was first installed at Broken Hill at the central Mine, has served its purpose and is obsolete. A newer type designed by Mr. Hoover is such a decided improvement that for ores and treatment conditions giving a stable froth, and where differential flotation or flotation sizing is not a desideratum, it does the work as well as could be required.

A Third type outlined by myself in consultation with Mr. Hoover has been under trial at Charlotte Street with promising results. A new plant has been designed along these lines, and is being built, and will be tried out in the course of the next few weeks.

I am inclined to think that one of the most important mechanical lines for investigation is that of a threshing out of the possibilities of plus pressure apparatus. I have been giving this considerable thought, but so far am ready to design in detail only a single type of apparatus. I have rather held this in abeyance, until we find out the possibilities of the new type of separating boxes.

The disposal of tailings and concentrates will in all cases form local and special problems.

1186 COMPLAINANTS' EXHIBIT.

Letter, Minerals Separation to Hyde, November 23, 1910.

Minerals Separation American Syndicate, Limited.

62 London Wall.

Dictated to M. E. P. by J. B.
Enclosures 2.

London, E. C., 23rd Nov. 1910.

James M. Hyde, Esq., c/o Bruce Mines, Ltd., Bruce, Ontario.

DEAR SIR: Bruce Mines.—Last night we received your cable of same date, turning the proposition down as unsuitable for our purposes, and thank you for your prompt decision. We at once replied authorizing you to visit the other properties in the vicinity which you had in mind.

Cables.—We enclose confirmatory copies of cables that have passed between us, viz.

Cables received from you on the 17th and 22nd and our replies of the 22nd and 23rd.

G. W. Thomson—Cobalt. We enclose you copy of letter received from that gentleman by our Chairman, dealing with the Zinc lead Silver property near Ottawa. We cabled you today to get into communication with Mr. Thomson, and we also cabled him to send you all particulars, from which, when received, you will
1187 gather whether the proposition is worth a visit. If so, please examine closely and find out whether business is possible on our lines—if not waste no time over it.

Mr. J. H. Curle has been detained here, but will in all probabilities leave for New York in a week's time, and will endeavour soon to come into touch with you, it being the resolve now to pay more direct attention to the U. S. A. and Canadian business, and to leave Mexico in abeyance for a time.

The White Mountain Mine.—From information given him, Mr. Hoover gives the following particulars—

"The White Mountain Mine is near Hancock, Michigan. The ore is supposed to carry 4% metallic copper and has hitherto been difficult to treat because of the fine dissemination of the copper through a sandstone gangue. The mine has been shut down for years, but there is said to be a thousand tons of the ore in the bin. We would like to have a few hundred weight of this ore for testing and research. Frank Klepetko of 42 Broadway has full information about this property and a report by him, made some time ago, could be secured for probably $150. Alexander Hamilton, Sydney, an attorney of Detroit is one of the principal share-holders. The shaft is said to be 400 feet deep."

After attending to the above matters, please proceed to Butte, Montana, and there go into the Zinc situation with the same minute care

which has attended your investigations of the various fields in Mexico.

Also test the tailings and various products you can secure from
1188 the copper mines and mills, saying as little about your connection as is consistent with getting information.

After Butte, it is our opinion now that you should proceed to Virginia City to look over the silver tailings there, and then perhaps to Ely, Nevada. These two latter points, however, are subject to alteration if it seems advisable.

We are, dear Sir,

Yours truly,

JOHN BALLOT,
For and on Behalf of
Minerals Separation American Syndicate, Limited.

COMPLAINANTS' EXHIBIT.

Cable, Minerals to Hyde, December 8, 1910.

Canadian Pacific Railway Company's Telegraph.

Via Toronto.

From London, 8 Dec., 1910.

To Jamehyde, Sudbury, Ont.:

ugparzuow	Re your wire of 7th Curle
tubogjouhb	still in
klehzuzfop	movements uncertain
epgemakdra	Do not alter
wusclosjog	your present
okonb	program

1189 COMPLAINANTS' EXHIBIT.

Cable, Minerals Separation to Hyde, December 9, 1910.

Cable to Mineration via Ottawa, Dec. 9, 1910.

Jiere	—— re your letter of the 23rd ult.
ugpes	—— re your telegram of the 8th
wueng	—— you are
atybe	—— fully aware that
hyawm	—— I would not
divco	—— contract for
kitya	—— more than
layne	—— one
wubar	—— year
guacf	—— .
huyob	—— I shall be
kukib	—— New York
ebbre	—— in a few days

uhkun —— telegraph to me
ukphe —— there
huded —— how
alavk —— and
weeky —— when you
olgcl —— propose to
anuzk —— arrange for
guety —— future
woirg —— work

1190 COMPLAINANTS' EXHIBIT.

Hyde Report, January 8, 1911.

The North American Situation.

The situation with regard to the possibility of doing business in North America, in so far as it has been possible to consider it during the past year, is in substance as follows:

Mexico.

Zinc Situation.

The work carried on in the Mexican field has demonstrated that the Mexican Zinc situation appears to offer promise of furnishing a piece of business of large possibilities as to profit, providing that it is possible to dispose of the Mexican Zinc ores and concentrates at substantially better prices than those now offered by the European smelters, or to smelt the same at a profit in Mexico, and also that the business entered upon and contracts for the ore, leases of properties and options on mines be negotiated before one of the several corporations now striving to enter the field manages to get the cream of the business.

My sudden departure from the field, before it was possible to canvass the zinc situation sufficiently thoroughly to enable me to submit a detailed and comprehensive report on the whole situation, leaves the matter, in so far as my information is concerned, practically where it was when I wrote from Parral giving an outline of the method by which the situation might be met, with the single exception that a closer inspection of the general smelting situation has revealed that the rise of the modern silver milling practice in
1191 Mexico has so greatly reduced the tonnage of siliceous silver ores now going to the customs smelters as to make the entry in general customs smelting work hazardous. The field for customs milling plants for mixed sulphide ores, and a zinc smeltery, with annex for treating its own valuable residues, appears to be sufficiently promising to warrant a completion of the investigation which I was carrying on, providing the American Syndicate cares to consider the possibility of entering into the business of zinc smelting in Mexico.

The American Statistics show that in spite of the very high pro-

tective tariff of 1c. per lb. on zinc in ores carrying over 25%, over 100,000 tons of zinc ores (principally "calamines") were imported from Mexico into the United States in the year 1909.

In many districts of Mexico zinc sulphide and calamine occur in quantity but have no market value under present conditions. As a consequence these ores can now be contracted for, or the mines purchased, at extremely reasonable terms.

The ore from the Tajo Mine at Parral, which is now en route to your London works, will throw much light on one of the most critical of Mexico's present metallurgical problems. Argentiferous ores of this type occur in many parts of the republic and are of little or no value under present conditions.

Copper Situation.

1192 My own tests offered very little hope of dealing satisfactorily with the chalcocitic copper ores of the Sonoran region. The tests which have so far been carried out in your London laboratory upon the samples sent from Cananea, Clifton and Morenci, have not given promise of success. It is possible that some combination of flotation work with the preliminary use of a soluble alkaline sulphide or hydrogen sulphide may solve this problem by coating these very fine particles of chalcocite with a film of the floatable mineral covellite. When opportunity arises, this subject should be given the most careful study possible, as the copper ores of a good part of the Southwest and also of at least a portion of the Utah region contain chalcocite which is not floatable by any of the methods so far tested.

The tonnage of ores of this type handled is very large and these ores should yield a considerable revenue in the form of royalties, if they could be treated by any cheap modification of the flotation processes.

The tests upon the Vanner feed and slimes tailings from Nacozari were very promising. Larger tests should be carried out on these, either at the London works or at an American Tests Works, when established, as it is very probable that a profitable piece of business can be done with Phelps Dodge & Co., so soon as your royalty policy with regard to American business has been defined and the final tests made on this material. There are many reasons other than mere additional saving which would incline these people to install a flotation unit in the place of their Vanner room.

1193 From information obtained from engineering friends, it seems possible that the ore of one or more of the mines of the region west of Guadalajara might possibly be advantageously treated by flotation, but the region as a whole is not particularly promising. I did not have the opportunity to visit the district.

The most promising copper district not visited by me is in the State of Michoacan. I am expecting full data with regard to a seemingly promising proposition in this state to reach me soon after I get an American headquarters established. A friend in Mexico has considerable data concerning it.

There are also a number of districts in Southern Mexico which contain mixed sulphide ores which are worthy of investigation.

I am now so familiar with the territory and my impressions are so fresh with regard to it that I deem it advisable to have a competent assistant working under my direction cover those promising portions of the country which I could not visit. This could be done with comparative rapidity if no attempt to make tests in the field were to be made.

Canada.

The Canadian situation may be considered under the following heads, the British Columbia copper situation, the British Columbia lead zinc situation, the Georgian Bay Copper District and the Sudbury Nickel district. With the exception of isolated occurrences of Molybdenite and graphite these regions are the only ones known of at the present time which seem to offer any opportunity for flotation processes.

1194 The British Columbia Copper Situation.

Both in the Rocky Mountain region and along the coast of British Columbia deposits of disseminated chalcopyrite occur. Some of these are said to be of large size and much promise. More data will have to be gathered concerning these deposits before it can be decided definitely as to whether or not they are of sufficient promise to warrant putting an assistant at work to investigate them during the coming summer.

The British Columbia Lead Zinc Situation.

In the Rocky Mountain district of British Columbia mixed ores of lead, zinc and silver occur. These have been made the subject of special study by the Department of Mines of the Dominion Government, which has issued a comprehensive report upon them by Mr. Walter Renton Ingalls and Phillip Argall. An investigation is now being carried on as to the possibility of smelting the zinc ore locally. A sum of $50,000 has been voted by the Dominion Parliament for this work.

This situation should be studied carefully, it is possible that it may offer some opportunities for the American Syndicate, but the field has not heretofore been considered of especial promise, because of the scattered nature of the ores and the heavy transportation costs.

Georgian Bay Copper District.

1195 There are a number of chalcopyrite bearing quartz veins of the Bruce Mines type in a district probably forty or more miles wide by perhaps one hundred miles long lying along the northern shore of Georgian Bay.

The best developed and best known of these are the Superior Cop-

per Mine, forty miles north of Sault Ste. Marie, Ont., on the line of the Algoma Central R. R., the Bruce Mines, the Hermina Mine near Walfort Sta., and the Massey Mine near Massey, Ont. In addition to these there are the Moose Lake prospects, the Cheney Mines about 20 miles north of Bruce Mines, the prospects in Desbarats location, not far from Bruce Mines, the Copper Queen Mine in Moran Toop, 24 miles north of Bruce Mine and a property owned by Frank Klepetko and associates. I am informed that there are several more concerning which I have no definite data at the present time.

The Massey and Hermina Mines are connected to the Canadian Pacific Railroad by short spur lines and are also within a few miles of shipping facilities on Georgian Bay.

The Moosehead Lake Mine is but a few miles across level country from both the Canadian Pacific Railway and Georgian Bay.

Some of the other properties are near transportation facilities and others are 15 to 25 miles back in the woods.

I am informed by reliable engineers that it is probable that a considerable tonnage of ore running 3% in copper can be obtained from a number of these properties.

1196 The Hermina, Massey and Superior Mines are sufficiently developed to allow of fairly satisfactory examination. They are white elephants on their owners hands and can probably be obtained by lease or purchase, or for stock in a new organization, on reasonable terms.

The less developed properties can undoubtedly be obtained on very reasonable terms. The price asked for the Moosehead Lake is but £3,000, to be paid in three equal installments.

When I was in this district the ground was so covered with snow and the conditions affecting travel and work were such that it was not then wise to try to gather much data concerning these properties. These conditions made my trip to the Superior Mines rather disappointing.

The district is sufficiently promising to warrant careful investigation during the coming summer. Mining and shipping costs should be especially low.

I have filed with you all the reports which I have been able to secure with regard to the Superior Mine and the Moosehead Lake property, and will supply your office with other data as I receive it from various sources.

Sudbury Nickel District.

The world's production of nickel comes almost entirely from two sources—the nickel silicate deposits of New Caledonia and the pyrrhotitic nickel-copper ores of the Sudbury District of Ontario.

1197 The nickel business of the world is now in the hands of a trust which has made enormous profits out of its exploitation.

The demand for nickel is increasing so rapidly that the Companies operating in the Sudbury district are constantly adding to their equipment of furnaces and increasing their output. The deposits of this region are of a peculiarly definite character, the nickel

occurs in great masses of pyrrhotite and chalcopyrite which has segregated out of the basic portion of a volcanic intrusion. Deposits of greater or less volume are found around the edge of this intrusion throughout its known area.

The working of these mines is a venture of very unusual safety for a mining business, as the deposits are large and continuous and the amounts of copper and nickel contained are sufficient to give the ore a relatively high value per ton. The metallurgy of these ores is extremely simple. The crude ore is mixed with a small amount of quartz and lime and from 10% to 17% of coke, and smelted semi-pyritically in blast furnaces. The matte from these furnaces is raised to about an 80% total content of nickel and copper in Bessemer Converters; the high grade matte is sent by the Canadian Copper Company to the U. S. for refining, and by the Mond Nickel Company to England for refining. Both of these concerns have made extraordinary profits from their enterprises.

There are a number of known deposits of large size in the district, which have not yet been opened up on a commercial scale. It is possible that from among these could be gathered together at a reasonable price, a sufficient number of mines of assured ton-
1198 nage to warrant entering into the business.

The Lake Superior Corporation of Sault Ste. Marie, Ont., owns a number of properties of great promise. They have by diamond drilling proved to their own satisfaction the presence of at least 500,000 tons of ore in properties which they control, a large part of which is by their statement of as good a grade as any that is being treated by the Companies now working in the district. The Lake Superior Corporation has become involved in so many large enterprises, which require all the capital which it can command, that it is desirous of disposing of its copper-nickel holdings. These are now under option to people in Chicago and a decision in the matter will be reached with these parties within the next 60 or 90 days. As the same people have previously dealt with them without being able to conclude the business, it is very possible that this property will be obtainable at a reasonable figure on time payments or for shares in a new company which will agree to find all capital necessary to develop the mines, treat the ores, and sell the products.

There are also a number of other known deposits of considerable promise, which are obtainable, and there are a number of tracts of swampy ground which could be prospected at small cost, which seem to offer considerable promise.

Around the edges of the bodies of heavy sulphide ore is considerable ore of a lower grade, which consists of portions of the basic rock impregnated with sulphides which in settling did not reach the mass of solid sulphides. Up to the present no attempts at
1199 concentrations have been made in the district, and ore of too low grade to smelt at once has either been left in place or thrown upon the dump. Apparently all of the sulphides which are valuable in this ore are easily recoverable by flotation methods. I am having a small sample of these ores tested in the London works.

I submit independently a number of letters and reports bearing upon this topic. When I have sufficient data to guide me to a final opinion as to the possibilities in the matter I will ask you for a decision as to whether or not you wish to undertake an enterprise of this type in which the flotation processes are likely to be a contributing factor of not very great importance. From many standpoints, the business seems to be a most unusually promising one. The amount of capital required to put the matter on a proper basis and give it sufficient working capital would probably be from £200,000 to £400,000.

United States of America.

Districts.

Among the districts of promise in the United States are the following:

The Butte district of Montana in which large deposits of zinc sulphide ores, needing concentration, are being developed and in which are being mined and concentrated an enormous tonnage of sulphide copper ores which if amenable to flotation treatment should offer large possibilities of royalty business.

The disseminated copper ores of the Bingham Cañon Dis-
1200 trict of Utah, the Ely District of Nevada and a number of districts of Arizona and New Mexico in which occur such well-known mines as the Miami, Ray Consolidated, etc., are being handled on an enormous scale. In a number of these districts the very fine chalcocite occurring in the ores may offer a considerable difficulty to flotation treatment, but in others it is possible that the sulphides are of such a nature as to be readily treated by flotation methods. These districts may yield a considerable volume of royalty business, and may possibly present opportunities for independent ventures.

The mixed sulphide ore region of Colorado and other portions of the Rocky Mountains, seems to be of great promise. Properties in the San Juan district, Colorado, are already under consideration and should be investigated carefully during the coming season.

The Comstock Lode region at Virginia City, Nevada, contains some very large deposits of tailings from silver sulphide ores, and is also said to contain a considerable tonnage of low grade sulphide ores in place. As the concentration of ores of this type in the Yellow Jacket mill has resulted in a recovery of 80% of the gold and silver contents in a pyrite concentrate it seems quite possible that flotation methods might be used here with considerable success. A contributory factor of possible large advantage is the fact that a very considerable volume of hot acid water is produced by these mines and flows in immediate proximity to the old mill tailings, dumps. No examination of these tailings can be undertaken to advantage until the winter snows have thawed.

1201 Headquarters.

A careful study of the whole situation throughout the year has led to the conclusion that the best place for a headquarters for the campaign both for the executive office and for test works, is Denver, Colo., or Salt Lake City, Utah, both of which are very centrally located from a mining standpoint. Work on the field may indicate that some other point will naturally become the center of activities through the first investigations being begun there and the first equipment for test purposes being erected to take care of some local enterprise. A large part of the business transactions will probably have to be carried out in New York City but it is probably much wiser, for the present at least, to keep the head quarters of the work at the centre of its activities in the heart of the mining districts. If the venture is successful in a large degree it is quite possible that it may be wise to have its headquarters transferred to the financial capital of America later on.

Assistants.

The territory in America requiring attention is so large and the deposits of possible interest are so scattered and of such varying nature that it will probably be advisable, in view of the fact that it is well to cover the field as rapidly as possible, to make use of several trained assistants investigating different districts under the direction of the General Manager.

1202 Test Works.

The past year's experience has demonstrated that very little, if any, test work should be undertaken in the field, and that so soon as it is possible to do so to the best advantage, a centrally located test works should be equipped at which tests on both a large and small scale can be made. It is quite possible that some small concentrating mill, or possibly a plant which has been used as a public test works, which is conveniently located upon a railroad, may be leased on reasonable terms, and equipped at small expense to give all the facilities that are needed for this work. If that can be done, it will be better policy to follow such a course than to go to the capital expense and loss of time necessary to erect a special works for this purpose.

At the present time it seems wise to investigate the Butte district first, as that is the region of greatest apparent promise and in which it is probable that results can be most rapidly attained.

JAMES M. HYDE.

8/1/11.

1203 COMPLAINANTS' EXHIBIT.

Copy Memorandum re Managership of Minerals Separation American Syndicate, Limited.

Memorandum re the Managership of Minerals Separation American Syndicate, Ltd.

The mining fields of the North American Continent are of great extent, varied nature and vast possibilities. They offer great opportunities for the exploitation of the Minerals Separation Ltd.'s patented flotation processes.

There are three factors upon which the success of ventures of the class being undertaken depends—the processes, the capital with which to exploit them, and the executive and creative business capacity of the manager.

The position of manager of the Minerals Separation American Syndicate Ltd. involves great responsibilities and the most varied and the most taxing variety of duties and functions which will have to be exercised in connection with reaping the possible advantages of flotation processes. The success of the venture will be contributed to as largely by the capacity of the manager as by any other factor. It will in fact be absolutely dependent upon his scientific knowledge, technical experience, adaptive ability, and creative and executive capacity. Any man possessing such abilities must be fully conscious of his qualifications and powers and of their commercial value. No man possessing such capacity will consider investing his energies in enterprises in which he is not adequately compensated for his time, and also allowed to create for himself an estate, by a just

1204 participation in the results of his labors. No mere salary, or salary combined with any terminable form of profit sharing can adequately compensate such a man for the expenditure of his business-creative ability.

In order for the position of manager of the Minerals Separation American Syndicate to be acceptable to me it would have to carry the following considerations.

1st. The manager should be empowered to draw up and carry out the plan of campaign, to hire and discharge employees necessary in the work, to instal testing facilities, when desirable (in connection with the Minerals Separation Ltd.'s technical staff), to conclude leases and options on properties, or purchase raw materials where such transactions do not involve an expenditure or obligation of more than a certain fixed sum, say £1000, it being however understood that whenever reasonable (and no delay being thereby caused to the Syndicate in the Manager's opinion) authority should be obtained from London for all transactions involving cash payments or obligations exceeding £500.

2nd. The position should not be considered to be subordinate to any appointive officer of Minerals Separation Ltd.

3rd. The salary should be such as similar engineering and business service usually commands and in no case less than is received by any other technical man connected with the exploitation of the Minerals Separation Ltd. processes.

4th. As partial compensation for creating the American
1205 business the manager should receive a two years' free option upon the right to subscribe at par, or issue price, to ten per cent of the capital stock of the Minerals Separation American Syndicate, and all business resulting on the American Continent from the use of the Minerals Separation processes or contributed toward or undertaken by the Minerals Separation Ltd., the Minerals Separation American Syndicate Ltd. or any offshoot from them launched during the term of office of the manager.

5th. All mining and milling propositions of sufficient promise shall be submitted to the directors for their consideration. The manager shall be considered at liberty to deal in his own interest as he may see fit, with any proposition not considered as desirable as a Minerals Separation American Syndicate Ltd. venture by the Board of Directors.

6th. There shall be a regular and prompt consideration of all communications submitted to the London office, and some official or officials shall be designated to regularly inform the manager of the results of such consideration, and to discuss the matters treated of in such communications with him.

1206 COMPLAINANTS' EXHIBIT.

Letter, Hyde to Minerals Separation American Syndicate, January 17, 1911.

62 London Wall, London, E. C.

17th January, 1911.

Mr. John Ballot, Chariman, Minerals Separation American Syndicate, Ltd., 62 London Wall, City.

DEAR SIR: I hereby withdraw the "memorandum re the managership of the Minerals Separation American Syndicate" which I placed in your hands a few days since. I have determined that it is not wise for me to contract with your Company for another year.

I have in my possession a variety of articles used in my work which were purchased with the funds of the Mexican Syndicate. These I will turn over to whomsoever you may indicate. A portion of them are now in London, others are in my trunk in New York, while others are packed with some of my personal effects in a box stored in Canada.

My expense account, when presented, will include the cost of my return to California.

It is possible that while engaged in exploratory and metallurgical work in the United States, I may have opportunity to use a flotation

process, or to recommend the adoption of one by some going concern. Will you kindly inform me as to the royalty you have decided to ask in America and the commission you are willing to pay on royalty business brought to you.

Respectfully yours,

JAMES M. HYDE.

1207 COMPLAINANTS' EXHIBIT.

Letter, Minerals Separation to Hyde, February 1, 1911.

Minerals Separation American Syndicate, Limited.

62 London Wall,

Dictated to M. E. P. by J. B.

London, E. C., 1st Feb., 1911.

J. M. Hyde, Esq., c/o H. C. Hoover, Esq., 1 London Wall Buildings, E. C.

DEAR SIR: In further reference to your letter of the 17th ult. and as personally explained on several occasions, I regret that you have decided not to extend your engagement with our Company for another year.

With regard to the various articles belonging to the Company in your possession, I shall be pleased, as already arranged between us, if you will have these delivered to Messrs. Beer-Sondheimer & Co. of New York for our account, and they will pay any expenses for freight, forwarding etc. thereon. We believe they have an agency at Salt Lake City as well, and so soon as we get the address from them, we shall be glad to forward it to you, should that centre be more convenient to you.

As you say, it is possible that while engaged in exploration and metallurgical work in the United States, you may have the opportunity to use our Flotation Process, or to recommend the
1208 adoption of the use of same to some going concerns. We wish to assure you that we shall be glad to consider any such business proposals on their merits as they come along, when the question of terms, either by royalty or otherwise, and also your commission for the introduction thereof, will be gone into at once and mutually arranged.

I am, dear Sir,

Yours truly, JOHN BALLOT,

For and on Behalf of Minerals Separation, Limited.

COMPLAINANTS' EXHIBIT.

Extract from Richards' Ore Dressing.

Sec. 869. Settling Fine Slimes by Means of Dissolved Substances and by Heat.

In sampling mill products that contain slimes carried in water it should be remembered that the extremely fine particles may not settle in several days or even weeks. However, there are various substances, small quantities of which dissolved in the water will coagulate the particles into comparatively large grains, which settle rapidly. Such a substance should be used in every important case, for the fine slimes are apt to contain a large percentage of the value, although they may be very small in weight. At one mill where the samples were allowed to settle only a short time before pouring off the water, assays of the tailings indicated 8 to 8½ ounces
1209 of silver per ton, but when the slimes were thoroughly settled, the tailings assay was found to be 18 ounces of silver per ton.

The following experiments, made in the author's laboratory, give some exact results with the use of lime, alum, common salt, hydrochloric acid and sulphuric acid. The slimes were obtained by stamping a quartz ore from North Brookfield, Nova Scotia, containing some slate, a fractional percentage of arsenopyrite and some free gold, using a punched screen with slots 1/40 inch wide and a height of discharge of 4 inches. After passing over amalgamated plates and a vanner, the coarse portion was settled out in small tanks, while the finest slimes were carried into a larger tank from which the water was pumped back to the stamp mill and used again. After the mill run was finished and the water had remained quiet in the large settling tank for half an hour, a large sample of the slimy water was taken from the top of this tank. Fifteen careful tests showed an average of 12.8% suspended matter, the extreme variation being from 12.3% to 13.0%. The results, given in Table 394 are based on this average. The tests were made on one liter quantities in breakers of such size that the water stood 6½ inches deep in them.

1210 Table 394.

Effects of Dissolved Substances in Settling Fine Slimes.

The figures below show the per cents. of total slime settled out, by the use of different per cents. of dissolved substances in different periods of time.

Time of settling.	Nothing added.	Common salt.				Ammonia alum.			
		½%	1%	2%	5%	½%	1%	2%	5%
½ hour	22	89	99	100	100	97	98	...	91
3 hours.....	72	98	98	100	98	100	100	100	...
14 hours.....	..	100	100	100	100	100	100	...	...
15 hours.....	..	...	...	...	...	...	...	...	...
20 hours.....	94	...	...	...	...	...	...	...	...

Potash Alum.

Time of settling.	½%	1%	2%	5%
½ hour	99(?)	94	98	95
3 hours	99	99	95	96
14 hours	100	..	100	..
15 hours	..	..	..	..
20 hours	..	..	..	..

CO Present After Adding Lime Water.

	.00365%	.00595%	.01136%	.02083%	.02885%	.04167%
½ hour	77	95	98	100	100	95
3 hours	91	100	100	100	100	98
14 hours	...	...	...	...	...	...
15 hours	100	98	100	100	96	...
20 hours	...	...	...	...	...	...

1211

Time of settling.	Hydrochloric acid			Sulphuric acid.		
	0.19%	0.39%	0.77%	0.15%	0.29%	0.57%
½ hour	100	100	100	100	96	99
14 hours	100	...	...	99	...	...

Varying proportions of salt and alum were added in fine powder and stirred in. Where lime (CaO) was used, it was added as clear (filtered) lime water, in order to eliminate any possible mechanical effect of suspended lime. The lime water contained 0.125% CaO; and the per cents., of CaO indicated in the table show the amount present after adding respectively 25, 50, 100, 200, 300 and 500 cc. of lime water to 1,000 cc. of the slime. The tests in which lime was used were also stirred, to produce a thorough mixture. In this connection, it should be noted that while the simple addition of even the smallest quantities of lime used caused the slime to agglomerate into distinct grains,* a fairly vigorous stirring caused it to form into comparatively large flakes which settled much more rapidly than the grains. Violent stirring, however, tended to break up these flakes and so hinder the settling somewhat. The stirring seemed also to help the coagulation in the case of salt and alum, but it did not produce large flakes.

1212 COMPLAINANTS' EXHIBIT.

Assignment, Froment to Ballot, November 17, 1903.

No. 12788/1902.

This indenture made the seventeenth day of November One thousand nine hundred and three between Alcide Froment of Traversella

*Before adding anything to the slime the suspended matter was too fine for the eye to distinguish individual.

in the Kingdom of Italy Engineer (hereinafter called the Vendor) of the one part and John Ballot of Salisbury House, Finsbury Circus in the City of London Esquire (hereinafter called the purchaser) of the other part whereas His Gracious Majesty King Edward VII by Letters Patent under the Seal of the Patent Office, bearing date the Fourth day of June One thousand nine hundred and two and numbered 12778 did for himself, his heirs and successors give and grant unto Henry Harris Lake of 45 Southampton Building in the County of Middlesex Patent Agent his executors, administrators and assigns, especial license, full power, sole privilege and authority to make, use, exercise and vend an Invention of "Improvements relating to the Concentration of Ores" within the United Kingdom of Great Britain and Ireland and Isle of Man, during the term of Fourteen Years from the day of the date of said Letters Patent, subject to the conditions in said Letters Patent contained. And whereas the said Letters Patent were granted to the said Henry Harris Lake on behalf of the Vendor as a communication from abroad. And whereas by an Indenture dated the 13th day of November 1903 and made between the said Henry Harris Lake of the one part and the Vendor of the other part of said Letters Patent and the full benefit thereof were duly assigned to the vendor as in the said Indenture mentioned. And
1213 whereas the Vendor has agreed with the purchaser to assign unto him all his right title and interest in and to the said invention in the manner hereinafter contained. Now this indenture witnesseth that in pursuance of said agreement, and in consideration of the sum of Two hundred and twenty five pounds sterling on or before the execution of these presents to the Vendor paid by the Purchaser (the receipt whereof is hereby acknowledged) he the Vendor Doth hereby as beneficial owner assign and convey unto the Purchaser his executors, administrators and assigns all those the said invention Letters Patent and premises hereinbefore mentioned, with all profit, benefit, commodity and advantage therefrom arising to hold the same during all the residue of the term of said Letters Patent, or any prolongation of the said term, unto the Purchaser his executors, administrators and assigns, for his and their sole use and benefit. Together with all improvements in the said invention which the Vendor may either by himself or in conjunction with any other person or persons invent or discover and the right for the Purchaser his executors, administrators and assigns to take out patents or other protection for the said invention or for any such improvements as aforesaid in any country colony or place except in the Kingdom of Italy that the Purchaser his executors, administrators or assigns may deem requisite or advisable. And the Vendor hereby covenants with the Purchaser that he the Vendor will forthwith forward or hand to the Purchaser the plans and diagrams of the plant relating to
1214 the said invention with a full description of the working of the process and that he the Vendor will from time to time forthwith communicate to the Purchaser his executors, administrators or assigns each and all such improvement or improvements as aforesaid and will in like manner forward or hand to the Purchaser his executors, administrators or assigns the plans and diagrams of the plant

relating to such improvement or improvements with full descriptions of the working of the same and that he will give to the Purchaser his executors, administrators and assigns the benefit of his advice in relation to the said invention and to any such improvement or improvements as aforesaid as and when the same may be required. And further that he the Vendor will from time to time and at all times hereafter make such declarations and execute and sign such deeds and documents and do such other acts and things as may be required by the Purchaser his executors, administrators or assigns for obtaining such further Patents or other protection as aforesaid and for vesting the same and the full benefit thereof in the purchaser his executors, administrators and assigns and the Vendor hereby covenants with the purchaser that notwithstanding anything by the Vendor done executed or omitted or knowingly suffered the said Letters Patent [are valid and]* subsisting [and in nowise void or voidable].*

In witness whereof the said parties have hereunto set their hands and seals the day and year first above written.

A. FROMENT. [SEAL.]

1215 Signed, sealed and delivered by the said Alcide Froment, in the presence of

G. B. ZANARDO.

9 Via Due Macelli, Rome.

Before me,
F. COSSIRINI,
British Proconsul.

JOHN BALLOT. [SEAL.]

Signed, sealed and delivered by the said John Ballot, in the presence of

G. B. ZANARDO.

9 Via Due Marcelli, Rome.

Before me,
F. COSSIRINI,
British Proconsul.

---

*Nine words are struck out.
A. F.
J. B.
F. C.

1216

Complainants' Exhibit Froment Italian Patent.

Provi. de Rome.

Regro Gen*le* Vol*e* 43, No. 63723.
Regro Attes. Vol. 156, No. 166.

Description de l'invention ayant pour titre:

Procédé pour l'enrichissement des minerais sulfurés cuivreux, plombeux, blendeux, etc. par les gaz combinés aux corps gras

par:—

Mr. Ing. Alcide Froment, a Traversella (Italie).

Les phénomènes suivants étudiés par l'inventeur, ont servi de base au procédé dont il est cas:

1. Lorsque les sulfures naturel réduits en poudre fine sont mouilles par un corps gras, ils ont une tendence à se réunir en sphérules et à venir flotter à la surface de l'eau.

2. Cette tendance est simplement retardée par le poids spécifique et contrariée par la gangue qui imprisonne les sulfures mouillés dans sa masse pulvérulente.

3. Si un gaz quelconque se degage dans cette masse, les bulles de ce gaz se recouvrent d'une enveloppe de sulfures lesquels s'élèvent facilement ainsi au dessus du liquide pour y venir former une espèce de magma métallique.

4. La formation de ces sphérules métallique est singulièrement activée si le gaz est à l'état naissant.

Ainsi par exemple, si dans un tube à éssais nous mettons une dizaine de grammes de minerai de cuivre sulfuré avec sa gangue, un gramme de calcaire, le tout réduit en poudre, si nous y ajoutons 30 grammes d'eau, quelques jouttes d'acide sulfurique et une mince couche d'huile ordinaire, si nous agitons pendant une seconde, nous verrons toute la chalcopyrite monter instantanément au

dessus du liquide et serrées les unes contre les autres, les sphérules métalliques viendront se grouper en magma nettement séparé du reste du liquide. Si le calcaire est en excés on de facile attaque, la rapidité de la séparation est tellement instantanée que la chalcopyrite est projetée avec force hors du récipient. Il y a donc une mesure a chercher pour un minerai es un calcaire donnés

Le peu de gangue entrainée mécaniquement retombe peu à peu et les sulfures restent à l'état de pureté presque complète. Cel est le principe.

Donc, la rapidité de la formation des sphérules et de leur ascension est en raison directe de la quantité de gaz produit en un même temps.

Exemple 1. Un minerai cuivreux contenant 12% de chalcopyrite 15% de pyrite de fer, 20% de carbonate de fer, 16% de dolomie et de calcite et 37% de gangues diverses, à été soumis au procédé dont il est cas. Il est à noter que ce minerai n'avait pu être enrichi économiquement par aucun moyen connu.

Il a suffi de quelques secondes seulement pour que le sulfure de cuivre soit complètement séparé du reste de la gangue dons laquelle l'analyse n' a pu décéler aucune trace de cuivre.

Exemple 2. Un minerai calciteux à 10% de plomb, invendable avec cette teneur, à été ainsi traité avec le même succès. Il y a plurieurs opérations distinctes mais liées dans la pratique du procédé: formation des sphérules et leur séparation de la gangue. Puis, separation du concentré d'avec l'huile et récupération de cette derniere qui ventre dans le circuit. Les concentrés se trouvent sous forme de tourteaux

Revendication.

Je revendique donc comme ma propriété exclusive et entière un procédé qui consiste à enrichir les minerais sulfures ou autres, minerais graphiteux et dérivés, terres

Complainants' Exhibit—Translation of Froment Italian Patent.

sulfureuses ou autres à l'aide des gaz quels qu' ils soient combinés avec un corps gras oléifiant (et non avec un corps huileux dérivé des bitumes, goudron, naphte, etc.) et quelque soit l'appareil sane lequel ce procédé puisse être appliqué.

Roma, 20 Maggio, 1902.
p.p. Ing. Alcide Froment,
G. B. Zanardo

Il Segratario
E. Livoni
Il Direttore Capo della Division I
F. Lanusol.

COMPLAINANTS' EXHIBIT.

Translation of Froment Italian Patent.

Regro Gienle, Vole 43, No. 63723.

Regro Attes, Vole 156, No. 166.

Description of the Invention Having for Title: A Process for Enriching Sulphide and Copper Ores, Lead Ore, and Blende by Gases Combined with Fatty Bodies.

By Mr. Ing. Alcide Froment, of Traversella, Italy.

The following phenomena, studied by the inventor, have served as the basis of the process which forms the subject of this invention.

1219 1. When the natural sulphides reduced to fine powder are moistened by a fatty substance, they have a tendency to unite in spherules and to float upon the surface of water.

2. This tendency is simply retarded by the specific weight, and opposed by the gangue which imprisons the moistened sulphides in its pulverulent mass.

3. If a gas of any kind is generated in this mass, the bubbles of this gas become covered with an envelope of sulphides and thus rise readily to the surface of the liquid where they form a kind of metallic magma.

4. The formation of these metallic spherules is singularly active if the gas is in a nascent state.

Thus for example, if in a test tube there is placed ten grammes of sulphuretted copper ore with its gangue, a gram of limestone, the

whole reduced to powder, and if there is added thereto 30 grammes of water, a few drops of sulphuric acid a thin layer of ordinary oil, and the mixture then agitated for a second, the whole of the copperpyrite will instantly rise to the top of the liquid. The metallic spherules pressed one against the other, will become grouped in a magma clearly separated from the remainder of the liquid. If the limestone is in excess or readily attackable, the rapidity of the separation is so great that the copperpyrite is forcibly ejected from the vessel. Therefore, a correct proportion has to be found for a given ore and a given limestone.

The small quantity of gangue mechanically entrapped
1220 gradually falls and the sulphides remain in a state of almost complete purity. Such is the principle.

Accordingly, the rapidity of the formation of the spherules and their ascension is in direct ratio to the quantity of gas produced in a given time.

Example 1.

A cuprous ore containing 12% of copperpyrite, 15% of iron pyrite, 20% of carbonate of iron, 16% of Dolomite and Calcite and 37% of various gangues have been submitted to said process. It should be stated that this could not have been enriched economically by any known means.

Only a few seconds were necessary for completely separating the sulphide of copper from the rest of the gangue in which no single trace of copper could be discovered by analysis.

Example 2.

A calcitous ore having 10% of lead and unmarketable with such a proportion, has been treated in the same manner and with the same success. There are several distinct but connected operations in the practical working of the process; the formation of the spherules and their separation from the gangue, then separation of the concentrate and the oil and recovery of this latter for re-entrance into the circuit of operations. The products of the concentration form oil cakes.

1221-22 Claim.

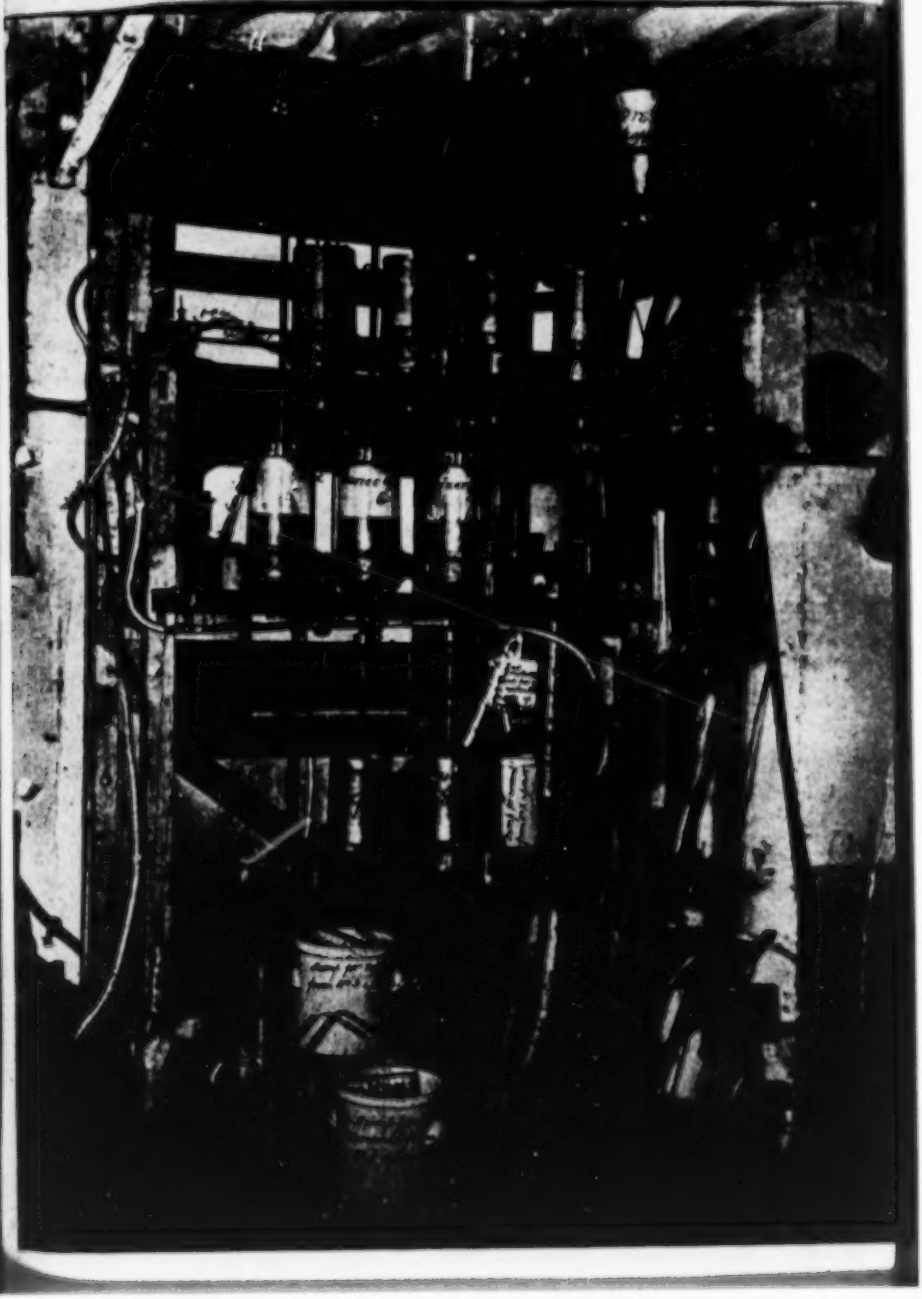
I therefore claim as being my exclusive and entire property a process consisting in enriching sulphide and other ores, graphitecus ores and their derivatives, sulphide earths or others, by means of gases which ever they may be, combined with an oily fat body (and not with an oily body derived from bitumens, tar, naptha, etc.,) and whatever may be the apparatus in which this process could be applied.

Rome, May 20, 1902. ALCIDE FROMENT,
By G. B. ZANARDO, *Attorney*.

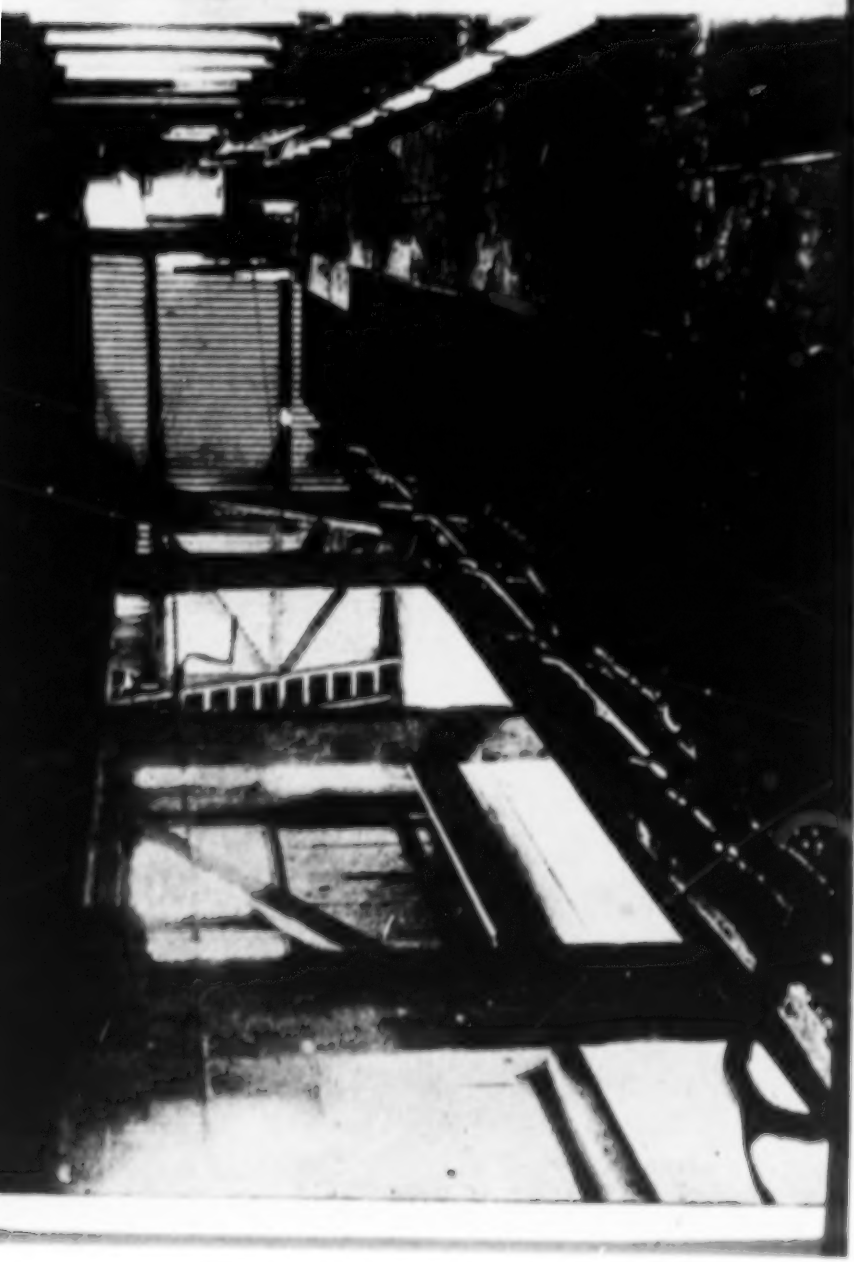
By the Secretary,
E. LIVONI.

The Head Director of the First Division,
F. LANUSO.

COMPLAINANTS' EXHIBIT
PHOTOGRAPH AUSTRALIAN CATTERMOLE PLANT



COMPLAINANTS' EXHIBIT
SULPHIDE CORPORATION RETREATMENT PLANT
PHOTOGRAPH 1.



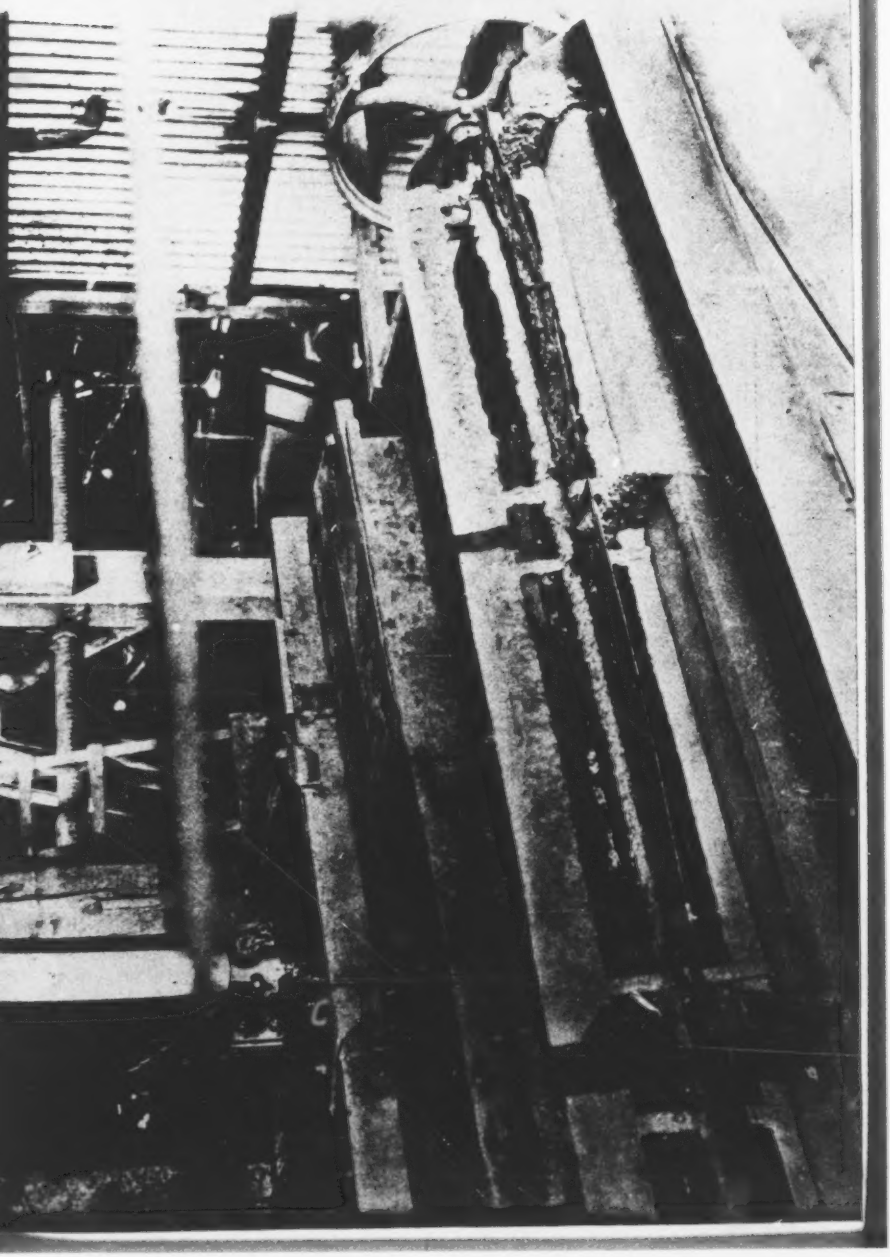
1222

COMPLAINANTS' EXHIBIT

[illegible] CORPORATION RETREATMENT PLANT

PHOTOGRAPH 2.

COMPLAINANTS' EXHIBIT
SULPHIDE CORPORATION RE TREATMENT PLANT
PHOTOGRAPH 3.



COMPLAINANTS' EXHIBIT

SULPHIDE CORPORATION RETREATMENT PLANT

PHOTOGRAPH 4.

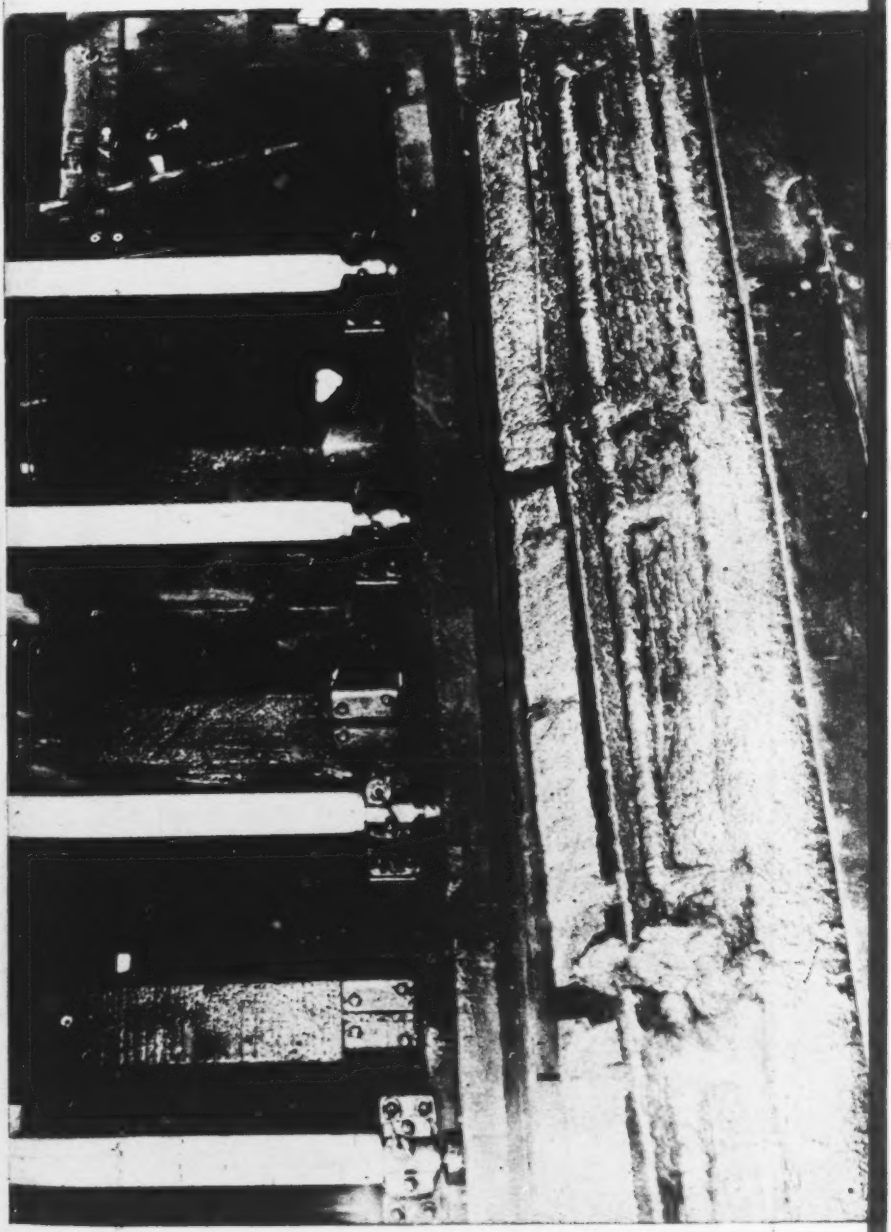


TABLE OF MATERIAL TREATED AND TONNAGE OF ZINC LEAD SILVER CONCENTRATES OBTAINED BY SULPHIDE CORPORATION LD. WITH MINERALS SEPARATION AGITATION FROTH PROCESS.-

Period	Material	Feed Tonnage		Concentrates Produced Tons		Total Value £ s	
Old Tailings Plant						{Calculated on average Price of Spelter for year}	
year ending 30 June 1906	Tailings	23709		8013		28174	
30 June 1907	do	65705		20621		76378	
30 June 1908	do	46394	135808	16513	45147	40240	143792
Minerals Separation Ltd Tailings Plant							
year ending 30 June 1908	Tailings	34506		12529		31988	
" 30 June 1909	do	40684	75190	14464	26993	34994	66982
New Mill Zinc Section							
[illegible] 1907	[illegible]	[illegible]		[illegible]		[illegible]	

		By products from	30,270		2040		28,230	
	30 June 1908	do -	167,142		54342		104,799	
	30 June 1909	do	157907		67981		138,518	
		By products from Pb section	179,997					
	30 June 1910	Tailings from annex	47,129		99767		218596	
		By products from Pb section	183,322					
	30 June 1911	Tailings from annex	2748		71,644		177447	
		By products from Pb section	180,200					
	30 June 1912	Dump Sluices	3645		69826		263,034	
		Old Tailings	457					
				940980		359,974		912.13
		Total		1,151,978		432,114		£ 1,127987

Joint Slimes Plant

year ending	30 June 1908	Slimes	4382		(Au Pb) 1.738 (Ag) 131 (Pb) 43			
	30 June 1909	do	2179		(Au Pb) 1.109			
	30 June 1910	do	19395	24956	(Au Pb) 10.164	13,185		26,164
		Total		1176934		445299		£ 1,154359

(No Model.)
1226-27

E. R. GABBETT

APPARATUS FOR MIXING LIQUIDS.

No. 444,345

Patented Jan. 6, 1891.

Fig 1

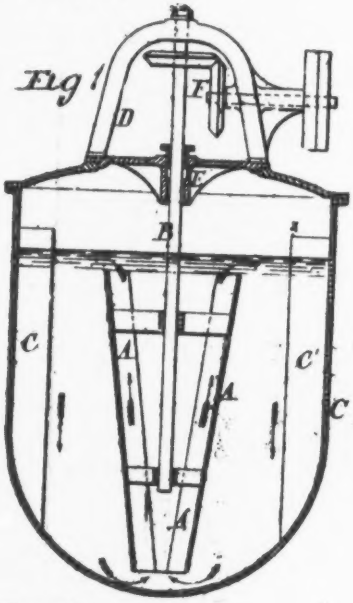


Fig 9

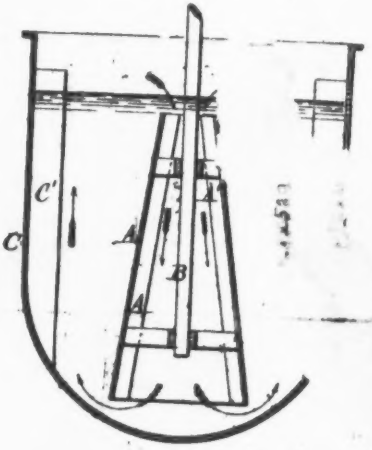


Fig 2

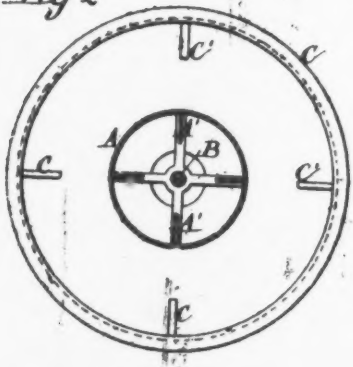


Fig 3

Fig 4

Fig 5

Fig 6

Fig 7

Fig 8

Witnesses
J. A. Rutherford
C. Brothers

Inventor
E. R. Gabbett
By G. and L. Norris
Attorneys

UNITED STATES PATENT OFFICE.

EDMOND R. GABBETT, OF OLD CHARLTON, ASSIGNOR OF ONE-HALF TO SAMUEL BAGSTER BOULTON, THOMAS BURT HAYWOOD, AND HAROLD EDWIN BOULTON, ALL OF LONDON, ENGLAND

APPARATUS FOR MIXING LIQUIDS

SPECIFICATION forming part of Letters Patent No. 444,345, dated January 6, 1891.

Application filed July [illegible]890. Serial No. 359 670. (No model.) Patented in England January 16, 1889, No. 840 in Belgium August 17, 1889, No. 87,411, and in France August 12, 1889, No. 200,153

To all whom it may concern.

Be it known that I, EDMOND RICH GABBETT, a citizen of England, residing at Old Charlton, in the county of Kent, England, have invented new and useful Improvements in Apparatus for Mixing, Incorporating, or Effecting the Circulation of Liquids and Semi-Liquids in Vessels, (for which patents have been obtained in Great Britain dated January 16, 1889, No. 840; in Belgium dated August 17, 1889, No. 87,411, and in France dated August 12, 1889, No. 200,153,) of which the following is a specification.

According to this invention I effect the mixing or incorporation of liquids or semi-liquids or the circulation of a liquid within a caldron or tank by the action of centrifugal force upon part of such liquid or liquids in such manner that a body of liquid is thereby continuously withdrawn from the bottom and delivered at the top, or vice versa, thus producing a continuously ascending or descending column of fluid within the apparatus and a corresponding movement in the contrary direction in the body of liquid outside the apparatus. By thus effecting the mixing or circulation of the liquid entirely by centrifugal action, I avoid in a great measure the loss of power due to the friction of mechanical devices moving in the liquid, such as occur in apparatus with helical propelling-blades and the like, heretofore employed.

The apparatus may be constructed in various ways for operating according to my invention. Thus, according to one arrangement I employ a shell of a conical, conoidal, paraboloidal, hemispherical, or trumpet-mouthed shape, fitted, if necessary, with internal ribs and immersed in a vertical position in the liquid, and having both its upper and lower ends open, the end of larger diameter being situated at top if the circulation is to be in an upward direction through it and at bottom if a downward circulation is required. The shell is fixed by suitable arms to a central strap carried in bearings above the caldron or vat, so that when more or less rapid rotary motion is imparted to it, and consequently to the body of liquid situated within it, the centrifugal force will act in the well-known manner upon such body of liquid, causing it to rise up on the inner wall of the shell and to flow over the upper edge, then into the body of liquid surrounding it, while at the same time fresh liquid will enter the lower end of the shell to replace that which is ejected at top.

The invention is applied in the manufacture of tar products, in sugar-refining, chemical works, distilleries, soap-works, treating ore for the extraction of gold, and for all purposes where liquids and solids require to be brought into intimate contact, or where a constant circulation of liquids is required.

The invention is illustrated by the accompanying drawings, in which—

Figure 1 shows a vertical section of one form of the above-described apparatus, and Fig. 2 shows a plan. Figs. 3 to 8 show modified forms of the shell. Fig 9 shows an inverted arrangement thereof.

A is a conical shell, having internal ribs A' and mounted on a shaft B, by which it is suspended within the vessel or tank C, containing the liquid to be acted upon, the shaft being carried at its upper end by a bracket D and guided by a bush or stuffing-box E on the cover of the vessel C. Assuming this vessel to be charged with liquid to the level indicated and the shell A to be rotated by suitable gearing, such as indicated at F, then the body of liquid within the shell being carried round with the same by means of the ribs A' the centrifugal force will cause the liquid to rise along the inclined inner surface of the shell and to be ejected into the surrounding liquid when arriving at the upper edge thereof, while at the same time the pressure of the surrounding column of liquid in the vessel C will cause fresh quantities of liquid to enter the lower end of the shell A to make good the quantity discharged at the top. Thus

OR COPY

a continuous circulation and consequent mixing of the liquid will be effected, as indicated by the arrows.

To prevent the carrying round of the body of liquid in the vessel C by its frictional contact with the outer surface of the shell A the vessel may be provided with projecting ribs C', as shown. This is, however, not absolutely necessary, and such rotation of the liquid may to some extent be prevented by making the vessel C rectangular instead of circular, as shown, or by arranging a set of two or more revolving shells such as A in the vessel, either grouped round a central driving-shaft or arranged in a row; also, instead of rotating the shell or shells A continuously in one and the same direction they may have their direction of rotation reversed after any desired intervals of time. This might be effected by applying two driving-pulleys carrying, respectively, an open and a crossed strap, which are shifted alternately onto a loose pulley, as is well understood. The circulation of the liquid can also be made to take place in the contrary direction to that described by inverting the position of the shell A, so that the centrifugal action will cause the liquid within it to travel in a downward direction, as shown at Fig. 9. The shell A may also, if desired, have an oscillating motion imparted to it, so as to move continuously or intermittently with its lower end to different parts of the vessel C, and thus cause the liquid to be drawn consecutively from such different parts. This might be effected by connecting the lower part of the shaft B, carrying the shell, to the upper part running in fixed bearings by a universal joint and imparting the described motion to and fro thereto by a crank, cam, or eccentric, and connecting-rod or by other suitable means. The shell A may be made to extend above the level of the liquid instead of being entirely immersed, as indicated.

Figs. 3 to 8 show diagram sections of various other forms which may be adopted for the revolving shell. Fig. 3 shows a paraboloidal shape; Fig. 4, a construction with hemispherical lower part and cylindrical upper part, the centrifugal action which drives the fluid upward being confined to the lower part. Fig. 5 shows an arrangement in which there are two or more concentric shells, on each of which a body of liquid will be made to ascend by centrifugal action, or there may be only two concentric shells, as at Fig. 6, forming a narrow annular space in which the liquid ascends, there being no opening in the inner shell. If the shell has its upper end immersed to a considerable extent below the liquid level the arrangement shown at Fig. 7 may be adopted, in which the top of the shell A is covered by a shield A^2, leaving a narrow annular orifice at *a* for the issue of the liquid. By this means the pressure of the column of liquid which would otherwise exist in the center of the shell is prevented from interfering with the centrifugal action. Fig. 8 shows a construction in which the lower part of the shell is made cylindrical, while the upper part is made trumpet-mouthed, the centrifugal action being in this case confined to the upper part, or the entire shell might be made of a trumpet-mouth shape.

If found advantageous to lessen the weight or load on the bearings of the shaft by which the shell is revolved, this can be effected by having an air-tight chamber connected to the shell or shaft. Thus, for instance, the shield A^2, (shown in Fig. 7,) being made hollow, will by its flotation partly carry the weight of the shell, &c., or in that of Fig. 6 if the inner vessel is covered and rendered air-tight the same purpose will be attained.

Although it is preferred to impart the necessary rotary motion to the shell by gearing, as described, yet it will be evident that other means might be employed, such as a turbine fitted on the shaft of the shell and driven by steam or other fluid.

The above-described invention is applicable with particular advantage in cases where the material to be acted upon requires to be maintained at a comparatively high temperature in order to maintain it in a liquid condition, as in such cases the employment of an ordinary circulating-pump within the vessel or caldron would be subject to considerable difficulties.

Having thus described the nature of this invention and the best means I know of carrying the same into practical effect, I claim—

1. An apparatus for mixing or circulating liquids, consisting of a closed tank or vessel for containing the liquid, a rotating conically-shaped shell secured to and suspended by a shaft vertically in the liquid and having upper and lower open ends of different diameters, through the interior of which shell the liquid is caused by centrifugal force to flow in one direction, while the liquid exterior of the shell is caused to flow in a reverse direction, and means for rotating the shell and causing such continuous circulation of the liquid within the tank or vessel and through the shell, substantially as described.

2. An apparatus for mixing or circulating liquids, consisting of a tank or vessel for containing the liquid, a rotating conically-shaped shell having a series of internal ribs immersed and suspended by a shaft vertically in the liquid and having upper and lower open ends of different diameters, and means for rotating the shell and causing a continuous circulation of the liquid within the tank and through the shell, substantially as described.

3. An apparatus for mixing or circulating liquids, consisting of a closed tank or caldron having on its internal surface a series of projecting ribs, the rotating conically-shaped

444,345

shell immersed and suspended by a shaft vertically in the liquid, provided on its internal surface with a series of ribs and having upper and lower open ends of different diameters, and means for rotating the shell and causing a continuous circulation of the liquid within the tank and through the shell, substantially as described

In testimony whereof I have signed my name to this specification, in the presence of two subscribing witnesses, this 11th day of July, A. D. 1890.

EDMOND R. GABBETT.

Witnesses
CHAS. D. ABEL,
JNO. P. M. MILLARD.

730

C. B. HEBRON

PROCESS OF CONCENTRATING ORES.

No. 474,829 Patented May 17, 1892.

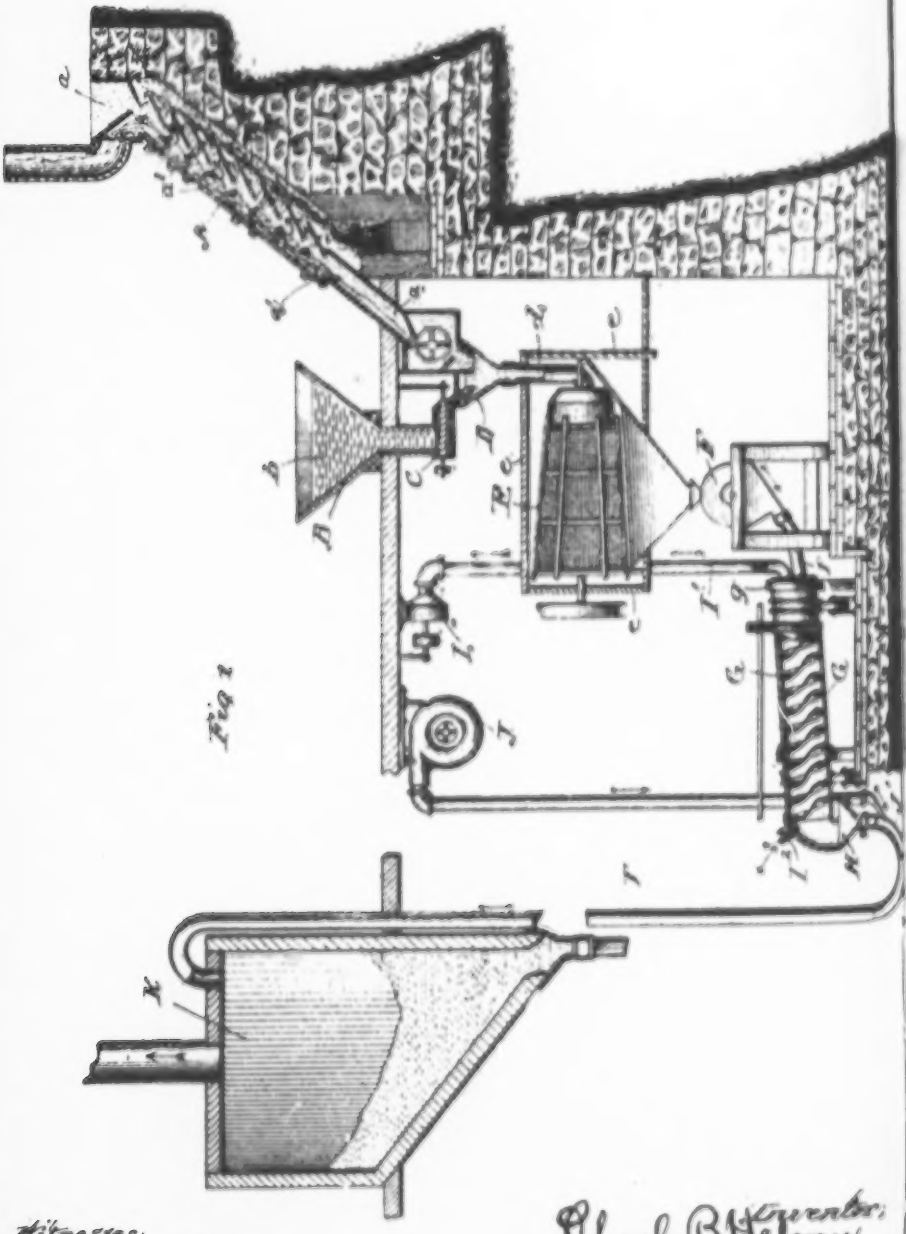


Fig 1

Witnesses;
Lieta S. Miller
Thomas L. Brown.

Charles B. Hebron, Inventor;
by Charles T. Brown, Atty.

(No Model.) 4 Sheets—Sheet 2.

C. B. HEBRON

PROCESS OF CONCENTRATING ORES.

No. 474,829. Patented May 17, 1892.

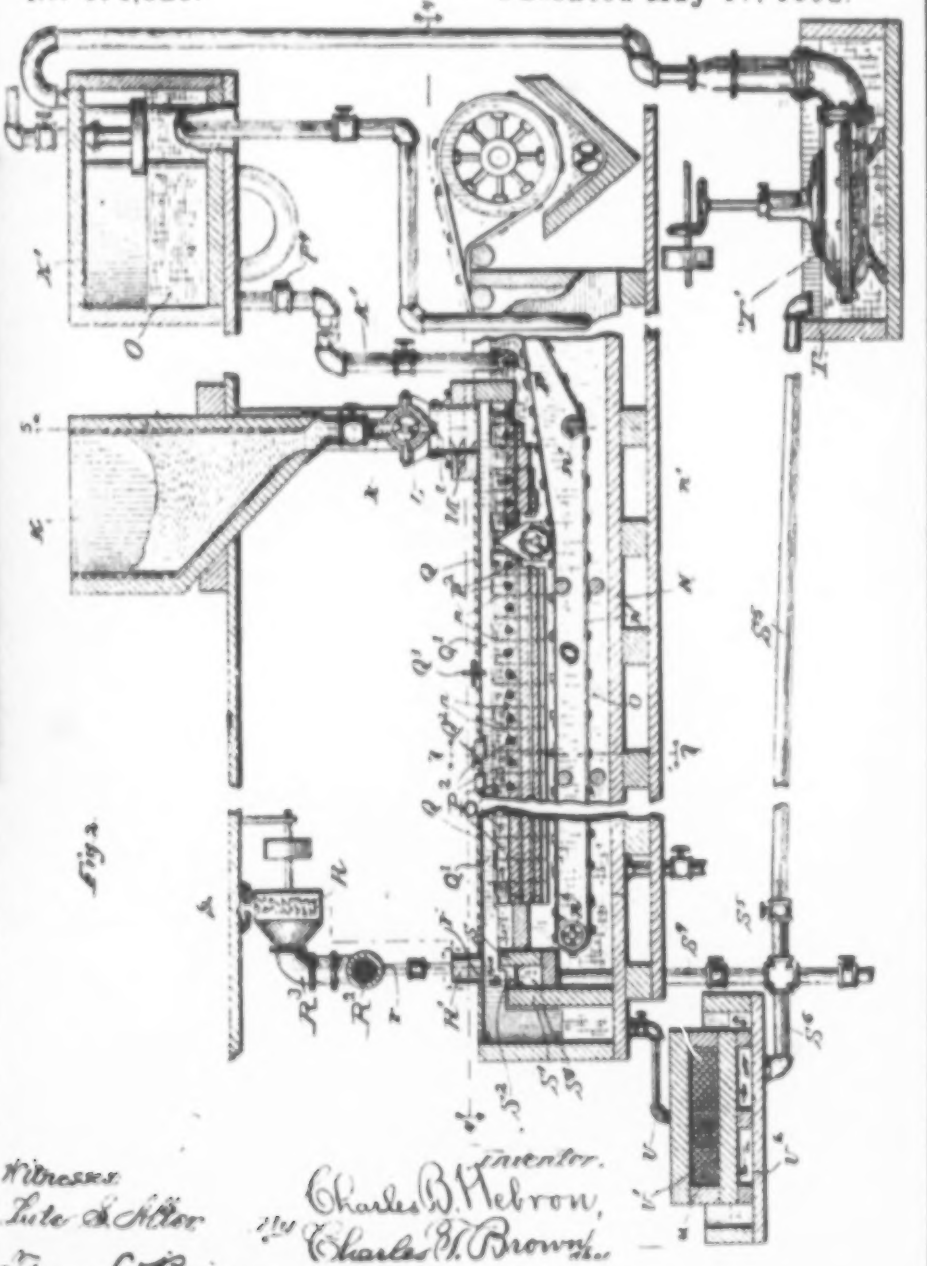


Fig 2.

Witnesses:
Tule L. Miller
Thos. L. Brown

Inventor.
Charles B. Hebron,
by Charles P. Brown & Co.

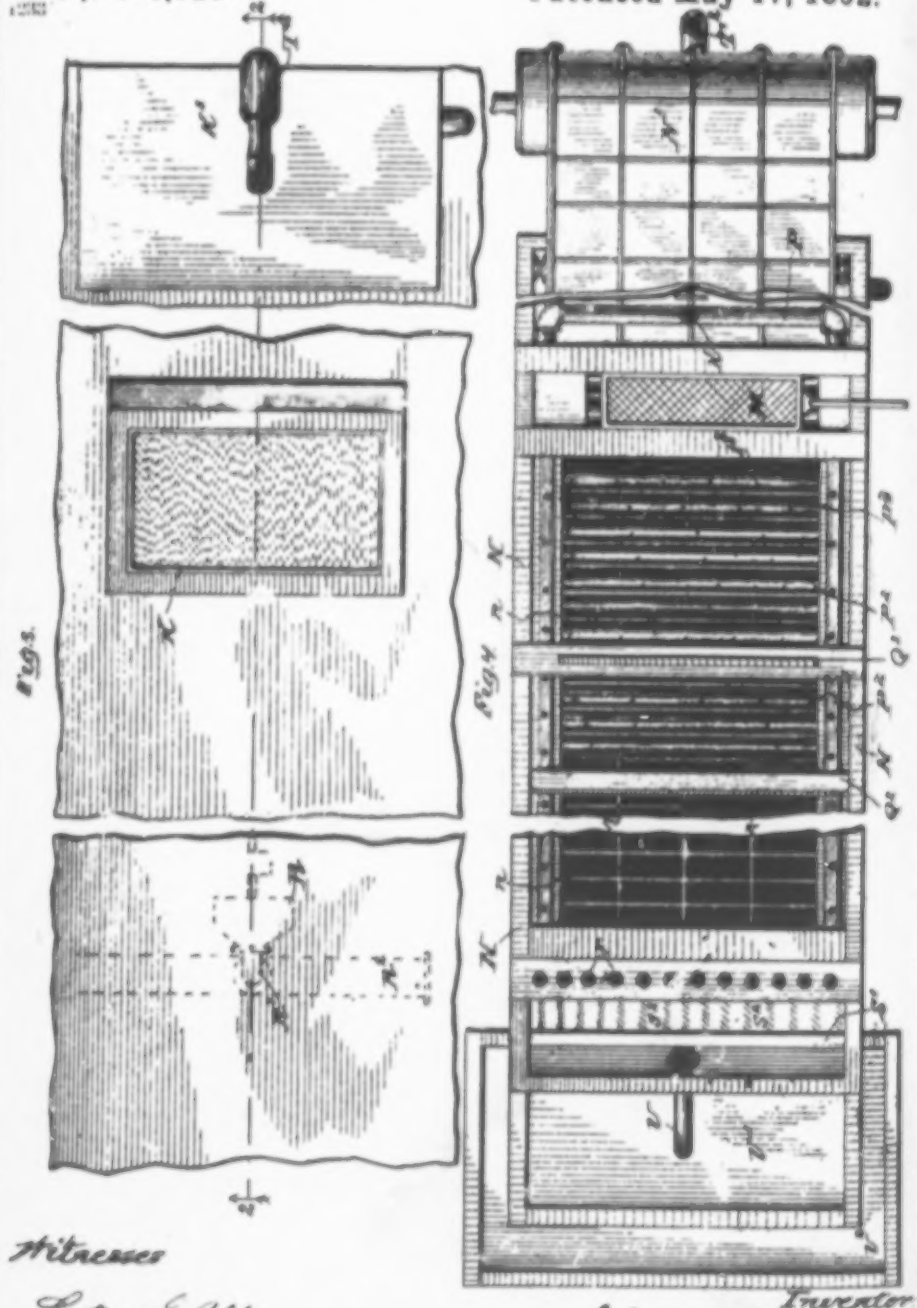
(No Model.)

C. B. HEBRON

PROCESS OF CONCENTRATING ORES

732

No. 474,829. Patented May 17, 1892.



Witnesses

Lutz & Alter

Inventor

Charles B Hebron

By

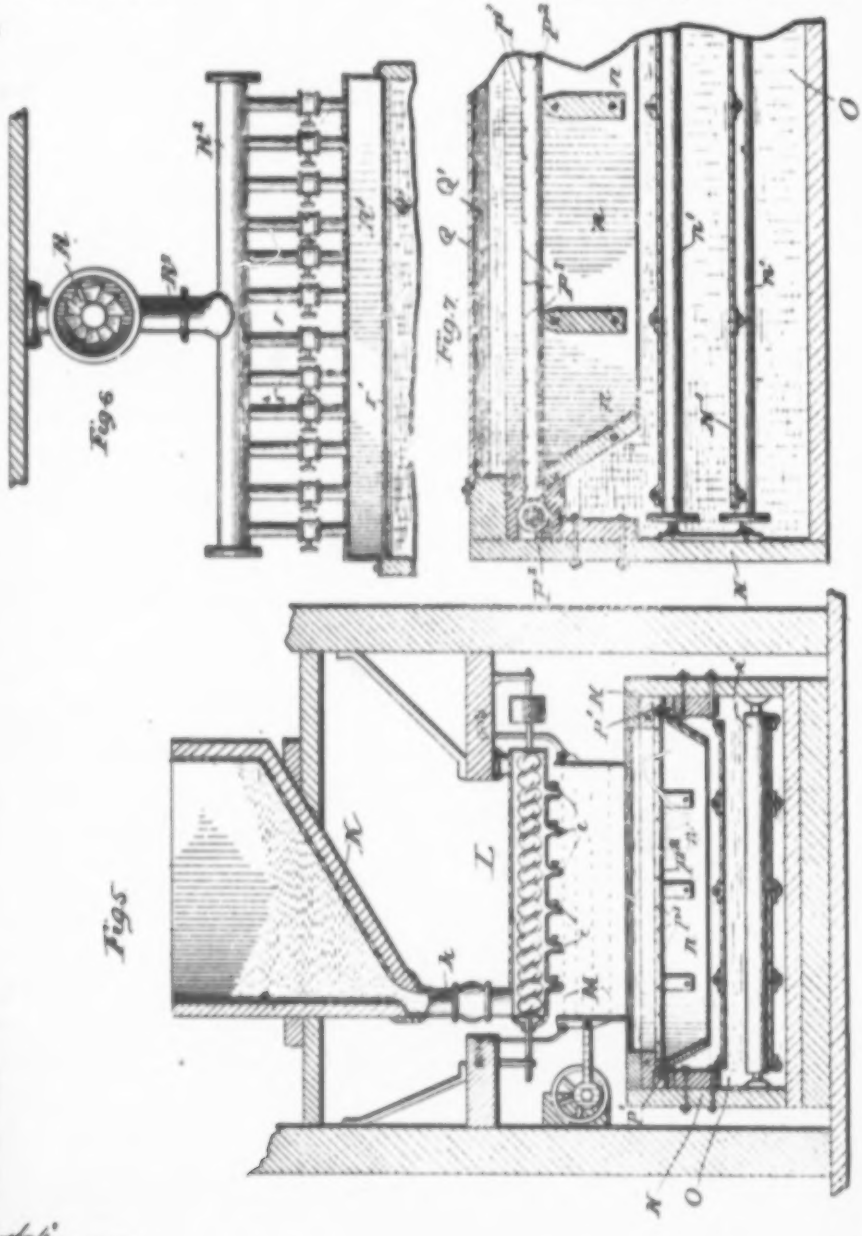
(No Model.) 4 Sheets—Sheet 4

C. B. HEBRON.

PROCESS OF CONCENTRATING ORES.

733

No. 474,829. Patented May 17, 1892.



Witnesses
Lula S. Alter
T. L. Brown

Inventor,
Charles B. Hebron
By Charles T. Brown

UNITED STATES PATENT OFFICE.

CHARLES B. HEBRON, OF DENVER, COLORADO, ASSIGNOR OF FIVE-SEVENTHS TO CARRIE J. EVERSON, OF SAME PLACE, MAMIE W. HUTCHINSON, OF TOPEKA, KANSAS, AND CHARLES T. BROWN, OF CHICAGO, ILLINOIS.

PROCESS OF CONCENTRATING ORES.

SPECIFICATION forming part of Letters Patent No. 474,829, dated May 17, 1892.

Application filed July 22, 1891. Serial No. 400,354. (No model.)

To all whom it may concern:

Be it known that I, CHARLES B. HEBRON, a citizen of the United States, residing at Denver, in the county of Arapahoe and State of Colorado, have invented certain new and useful Improvements in Processes for the Concentration of Ores; and I do declare the following to be a full, clear, and exact description of the invention, such as will enable others skilled in the art to which it appertains to practice the same.

My invention relates to a process for the separation or concentration of certain kinds of ores heretofore found particularly intractable and practically impossible to separate; and it consists of certain doings constituting an improvement on the process heretofore invented by Carrie J. Everson and myself jointly, such joint invention being described and claimed in the application for a patent filed by us on the 1st day of September, 1891, Serial No. 404,400, allowed January 9, 1892, and may be considered as founded upon the same principles as is the process described in the application referred to, in conjunction with other principles not therein set forth. The process described in such joint application consists, briefly stated, in first pulverizing the ore to the proper fineness, (which pulverization must in every instance reach the cleavage or disintegration of the ore and may be much finer than that required to reach such cleavage or disintegration in cases where the mineral particles of the ore are in coarse dissemination in the rock, or where free metal is mechanically combined with rock,) after such pulverization applying to the ore while in a dry state a quantity of dry buoyant material, with proper pressure and movement, as by rubbing under pressure—say with the use of burrs or equivalent mechanical devices—whereby the buoy stock is forced into the openings or interstices existing between the atoms constituting the porous metallic and mineral particles, or is caused to adhere to the irregular or roughened surface of such metallic and mineral particles and said particles thereby made buoyant, and the ore stock thus prepared being subsequently delivered to or upon the surface of the water in suitable manner to subject the same to flotation thereupon, the buoyant mineral and metal particles remaining as a scum upon the water, while the rock matrix of the ore stock, or, in mining parlance, the "gangue" thereof, settles, resulting in separation.

It is to be understood that the foregoing briefly-described process and the herein described and claimed process are based upon the difference in formation between the rock crystals and the mineral and metal particles constituting the ore adapted for treatment by this process, the latter being porous, while the former are crystalline in character and the surface thereof glassy, whereby the buoy stock may be said to attack the disintegrated metallic and mineral particles without affecting the smooth rock crystals, such difference in structure between the mineral and metal particles and the rock crystals being distinctly marked in the class of ores I seek to separate by this process.

My present invention or discovery relates to the preparation of the ore for the presentation thereto of the buoy stock in such manner and by such means that the mineral and metal particles contained in such ore stock are made to receive greater quantities of such buoy stock than has been heretofore possible.

In properly-pulverized ore of the class or kind which this invention relates to the mineral and metal particles, being of the character hereinbefore described, when at about climatic temperature contain and are surrounded by particles of air or other gases, and the presence of such air or other gases retards, hinders, and partially prevents the attachment to and joining with such particles of as large a bulk of buoy stock as is possible when such air or other gases are not present. Further, if the openings, cells, cavities, depressions, or pores contained in and on the mineral and metal particles in the ore are enlarged, (particularly when such enlargement is obtained in connection with the absence of air or other gases in or on such particles,) and at such time the buoy stock is presented thereto and thoroughly pressed therein, the capacity of such particles for containing and mechanically joining with the buoy-stock material is increased.

The object of my invention is to obtain greater buoyancy in the joined mineral and

metal particles and buoy stock than has heretofore been obtained, and to attain such object I expel from such mineral and metal particles an appreciable quantity of the air and other gases contained in the openings, cells, cavities, depressions, or pores thereof, or surrounding them at the time of presenting thereto and pressing thereinto the buoy stock by producing as far as practicable a vacuum in the receptacle containing the ore and the buoy stock and the mechanism effecting the joining of the mineral and metal particles of the ore with the particles of the buoy stock, or, and preferably, by applying heat to the ore, thereby obtaining the desired expulsion of air and other gases prior to the presentation to and pressing of such buoy stock into and upon the mineral and metal particles of the ore, and retaining such heated condition in the ore until such buoy stock is properly brought in contact with the mineral and metal particles thereof and pressed therein and upon, thus producing at the same time an enlargement of the openings, cells, cavities, depressions, or pores contained in and on the mineral and metal particles.

In order to heat the previously-pulverized ore, it is placed in a receptacle, where it is subjected to a dry artificial heat of considerable intensity, but not sufficient to materially volatilize the values thereof.

I have found the following-described mechanical devices used in the herein-stated manner efficient in reducing my invention to practice, to wit: an infusion fire-blast rotary cylindrical furnace, or the equivalent thereof, into which the ore stock is continuously fed at one end and conveyed through the fire-chamber thereof to and discharged at the other end onto a shaking or rotating screen, which is closely housed for the purpose of checking radiation of heat, an automatic conveyer by which the buoy stock is fed in a cold and preferably chilled condition from its storage-receptacle to the same screen on which the heated ore is being fed, whereby the buoy stock and the pulverized ore passing through the meshes of the rapidly-oscillating screens are commingled prior to their delivery therefrom; suitably-adjusted rotary burr-disks between which the ore and buoy stock are delivered from the screen, whereby the buoy stock particles are pressed into and upon the heated mineral and metal particles of the ore; a cooling and aerating device by which the ore stock thus far prepared is cooled and aerated, and an ore-separator.

The amount of buoy stock supplied to the ore is determined by the bulk of metal and mineral contained in the ore. The buoy stock should, I find, be approximately equivalent in bulk to the bulk of such mineral, the ore having prior to the delivery thereof to the oscillating or rotary screen where it is first brought in contact with the buoy stock been heated in the furnace to considerable intensity and in excess of the temperature required to properly expel the air and other gases therefrom and obtain the maximum enlargement of the openings, cells, cavities, depressions, or pores thereof. Provision is thereby made for the partial cooling of the ore, which results from contact with the mineral and metal particles thereof, and pressing thereinto and thereon of the cold or chilled buoy stock particles and from radiation, and such excess must be sufficient to maintain in the ore stock while between the burr-disks the heated condition necessary for preserving the practical expulsion of the air and other gases from the mineral and metal particles, so that the partial vacuumed condition attained in the openings, cells, cavities, depressions, or pores of the mineral and metallic particles shall not be broken until the buoy stock particles have been joined thereto. To aerate such joined metallic and mineral and buoy-stock particles a blast or current of cold and preferably chilled air is blown through the so-far-prepared ore stock as it falls from the slots in the hopper, into which it is delivered from the burrs, or as it passes through a conveyer before reaching such hopper. This blast of cold or chilled air, in addition to aerating and cooling the nearly-prepared ore stock, can be of sufficient volume and force to convey the ore stock to a receptacle, from which it is taken by an automatic conveyer in proper quantities to supply the working capacity of the separator.

A suitable separator for use in this process consists of a rectangular tank placed in a horizontal position and nearly filled with liquid, the width of which tank is determined by the capacity desired, the depth being sufficient to have contained under the surface of the liquid therein partitions provided for stalling the current of the liquid in the tank below the surface thereof, and for an endless apron-belt movable beneath such partitions with the necessary idlers, pulley-rollers, and supports thereof, on which apron-belt the rock matrix settles, and by the movement of which it is conveyed from the tank to the determined place of deposit therefor. The movement of the apron-belt is toward the head of the tank, and it rises out of the same on an incline at the head, carrying the rock matrix settled thereon out of the tank, and the liquid in the tank is discharged therefrom at the tail thereof, floating the concentrates thereupon. The partitions designed to stall the liquid in the tank extend from one side thereof to the other, and from near the surface of the liquid—that is, from less than one-half inch thereof—to near the endless apron-belt—say within less than one-half inch thereof. The liquid supplied the tank and forming the overflow at the tail thereof is delivered through horizontal pipes extending across the tank between the stalls, the top of such pipes being about one and one-half inches below the top of the stall-partitions, and such pipes being perforated on their upper halves, the liquid which

is contained therein under pressure will, as it is forced through the perforations, produce an effervescing condition at and near the surface of the liquid in the tank, such effervescing condition of the liquid tending to loosen the rock matrix from the buoyed values of the ore stock in the surface-fed charge, causing the rock particles to break away from the same at the surface of the liquid and settle through it between the stall-partitions to the moving endless apron-belt. These perforated pipes, through which the liquid is supplied to the tank, extend from a point underneath the feed-screens for about one-fifth to one-third the length of the separator-tank. For the distance between the tail terminus of this series of pipes and the tail of the series of partitions for stalling the liquid all effervescence ceases, allowing the liquid between such partition-stalls to be calm, thereby offering less obstruction to the settling of the more exhausted rock particles which remain suspended in the shallow current above such stall-partitions for a greater time and distance than the coarser particles of the rock matrix, permitting this more exhausted residuum to settle upon the moving endless apron-belt at points nearer the tail of the separator. The prepared ore stock delivered upon the rapidly-oscillating feed-screens passes through the series of screens and is delivered to the surface of the liquid in the tank in the form of a continuous dust-cloud, and the metallic and mineral values of the ore stock contained therein are separated from the rock matrix, as heretofore described. The longitudinal movement of the floating film or scum containing the values of the ore must be in pace with the supply of ore from the feed, which must be only rapid enough to thinly cover the liquid-surface. A chamber exists between the liquid-surface and the tank-covering, (which should be transparent,) through which a gentle suction air-blast is drawn over the scum longitudinally and exhausted through air-flues rising above the tail end of the separator-tank by means of a suction-fan. This air-blast causes the scum or floating film to move upon the liquid-surface rapidly, thereby increasing the capacity of the separator and admitting of the use of a slow and sluggish surface current above the upper edges of the stall-partitions. This torpid movement of the liquid-current allows the rock particles to settle more easily than if capacity was obtained by a rapid movement of the liquid-surface, which would impart such momentum as to hold the rock particles longer in suspension, and therefore requiring much greater length of tank-surface to obtain a good separation.

The liquid commonly used in the separator-tank is water; but in northern latitudes or in a high altitude, particularly in the winter season, it will be found desirable to use a liquid less subject to freezing than water, and as in this process the product and the residuum of the pulverized ore stock are severally removed from the separator-tank, leaving the liquid employed therein when delivered at the tail end of the apparatus in condition to be returned to the storage and again used, any liquid of sufficient fluidity whereof the specific gravity is less than the specific gravity of the rock matrix can be employed, provided, of course, the separator-tank and its appurtenances coming in contact with the liquid are constructed of material well adapted to resist the action thereof. Hence common brine (a solution of sodium chloride) is practically available, and other liquids might be used.

Between ore specially adapted for treatment by this process and ore unfit to be treated thereby there is found ore wherein the mineral and metallic particles are so dense and compact in physical structure that the buoyant character necessary for the best results in the separator-tank where water is employed as the liquid is somewhat difficult to obtain, even by the use of buoyant particles jcined thereto in the manner hereinbefore described, and in such case it will be found highly desirable that brine or some liquid having greater specific gravity than water be employed as a substitute thereof.

In the drawings accompanying and forming a part of this specification mechanisms are illustrated adapted to perform the several functions demanded thereof in the carrying out of this process, and in such drawings—

Figure 1 is a cross-sectional view of a continuous fire-blast furnace and an elevation of the machinery employed therewith, whereby the pulverized ore is properly prepared, as herein described, and deposited in the storage-chamber, such storage-chamber being also shown in cross-section in said figure; Fig. 2, a longitudinal sectional view of an ore-separator on line 2 2 of Fig. 3; Fig. 3, a plan view of a liquid-storage and pipes thereinto and therefrom and a prepared ore-stock storage, forming appurtenances to such ore-separator; Fig. 4, a longitudinal sectional view on line 4 4 of Fig. 2, viewed in the direction indicated by the arrows, the top of the tank of the ore-separator being transparent and so exposing to view the several parts in the tank of the separator; Fig. 5, a vertical cross-section on line 5 5 of Fig. 2, viewed in the direction of the arrows; Fig. 6, a vertical cross-section on line 6 6, also viewed in the direction indicated by the arrows; Fig. 7, a vertical cross-section of a portion of the device, on an enlarged scale, on lines 7 7 of Fig. 2, viewed in the direction indicated by the arrows.

Similar letters of reference are employed to indicate a part where more than one view thereof is shown.

A is a continuous fire-blast furnace, *a*, the pulverized ore passing through A, and *a'* the fire-blast of such furnace.

B is a storage-receptacle for the mate-

rial of buoyant character required in this process, which material I prefer shall ordinarily consist of pulverized charcoal.

C is an automatic conveyer, by which the prepared buoy stock is fed from storage-receptacle B to trough D.

E is a rotatory screen, and *e* the housing thereof.

The pulverized and heated ore *a* is delivered from the furnace A, through trough D and pipe *d*, into the rotary screen E, and *b* is the buoyant material contained in storage B, which is also delivered by conveyer C into the trough D, along with the pulverized and heated ore *a*, and passing therewith into the rotary screen E. Rotary burr-disks are contained in the frame F. Such disks being well known in the art, I do not deem it necessary to expose the same to view.

G is a rotary conveyer by which the ore stock delivered thereto from spout *f*, after having passed through the burr-disks, is conveyed to trough H.

I is the fan by which air, preferably cooled or chilled, is drawn through the pipe I' from cock I^2 in the conveyer G, producing a gentle current over the contents of the conveyer from such cock I^2 to the point in the non-rotatable head *g* thereof, where pipe I' is secured.

J is a fan by which a current of air can be forced into the pipe J' and the contents of such pipe be thereby elevated and deposited into the storage-receptacle K, from which they can be delivered to the ore-separator.

The ore-separator which I prefer to use is one wherein liquid is employed as the fluid, through which, by the action of gravity, certain parts of ore stock, as hereinafter explained, will fall and on which other parts of such prepared ore stock will float to the point of delivery therefrom.

K', Fig. 2, is a storage-receptacle for the liquid required in the separator. From storage-receptacle K a pipe *k*, having a suitable valve therein, extends to the conveyer L, from which conveyer the prepared ore stock is dropped through discharge pipes or nipples *l l* to the shaking-screens M M, through which screens such prepared ore stock passes and from which it is delivered upon the surface of the liquid O, contained in the rectangular tank N. From the storage-receptacle K' a pipe *k'* extends into the tank N, and through such pipe the liquid O passes into such tank.

n n are the partitions provided in the tank N.

N' is an endless movable apron-belt beneath such partitions, and *n' n'* are the idlers or pulley-rollers supporting the belt.

P is a horizontal pipe extending laterally across the tank N below the surface of the liquid contained therein.

P' P' are horizontal pipes extending longitudinally for a portion of the length of the tank, and P^2 P^2 are horizontal pipes extending laterally underneath the surface of the liquid in the tank.

P^3 P^3 are holes in the pipes P^2 P^2. The liquid passing from the tank K' through the pipe *k'* extends through the pipes P P' P^2 and enters the tank through holes P^3 in pipes P^2. The proper pressure under which the liquid passes out of the holes P^3 P^3 can be determined by valve P^4 in pipe *k'*.

Q is the transparent cover of the tank.

Q' is the chamber extending between the surface of the liquid and the cover.

R is a suction-fan, and *r r* are pipes extending from chamber R' to horizontal pipe R^2, such horizontal pipe being connected to fan R by pipe R^3. *r'* is a screen interposed between the chamber R' and the chamber Q'. The movement of the suction-fan R creates the air-blast hereinbefore referred to in the chamber Q', between the open slide Q^2 and the chamber R'.

Q^3 is a vertical slide extending from the cover Q through the chamber Q' to near the surface of the liquid O and prevents any blast or current of air above such liquid between such slide Q^3 and the screens M.

S S' are bridge-walls over which the liquid and the prepared ore stock thereon passes.

S^2 is a screen or perforated plate between the bridge-walls S S', through which much of the liquid passing over bridge-wall S can flow into the chamber S^3 underneath the screen, and from thence through pipe S^4 to waste or to pipe S^5, through which it flows to receptacle T, from which, by the pump T', it can be raised through the pipe T^2 into the receptacle K'. The liquid and prepared ore stock thereon, containing the values of the ore passing over the bridge-wall S', flow through the pipe U into the receptacle U'.

u u are screens in receptacle U', through which the liquid can flow into the receptacle U^2, from which receptacle it can flow through pipe S^5 to receptacle T. The prepared ore stock remains in the receptacle U', from which it is taken when desired.

It will be evident to those skilled in the art that liquid employed as a suspensive fluid in the manner described is not the sole way in which suspension in different strata for sufficient time to separate the buoyed mineral and metallic particles from the rock matrix of the ore can be effected, as any of the well-known stratifying mechanical devices can be used as an element of this process for the purpose of separating the heavier from the lighter particles, and thereby stratifying the ore stock, and when the ore prepared by this process is properly subjected to such mechanical devices it will be found that the buoyed mineral and metallic particles will, being lighter, obtain the upper strata.

Having thus described my invention, what I claim, and desire to secure by Letters Patent, is—

1. The herein-described process for concen

trating ore, consisting of producing a vacuumed condition in the mineral and metallic particles of properly-pulverized ore, of presenting to such ore while in such vacuumed condition and by movement and pressure mechanically joining with the mineral and metallic particles thereof particles of buoyant material, of aerating such buoyed mineral and metallic particles, and of subjecting such prepared and aerated ore stock to controllable stratifying agencies, whereby the rock matrix of the ore stock is caused to settle away from the buoyed mineral and metallic particles thereof and is thereby separated from such buoyed mineral and metallic particles, substantially as described.

2. The herein-described process for concentrating ore, consisting of producing by heat a vacuumed and expanded condition in the mineral and metallic particles of properly-pulverized ore, of presenting to such ore while in a heated, vacuumed, and expanded condition and by movement and pressure mechanically joining with the mineral and metallic particles thereof particles of buoyant material, of cooling and aerating such buoyed mineral and metallic particles, and of subjecting such prepared ore stock to controllable stratifying agencies, whereby the rock matrix of the ore stock is caused to settle away from the buoyed mineral and metallic particles thereof and is thereby separated from such buoyed mineral and metallic particles, substantially as described.

3. The herein-described process for concentrating ore, consisting of producing by heat a vacuumed and expanded condition in the mineral and metallic particles of the ore, of presenting to such ore while in a heated, vacuumed, and expanded condition and by movement and pressure mechanically joining with the mineral and metallic particles thereof particles of buoyant material, of cooling and aerating such buoyed mineral and metallic particles, and of presenting such prepared ore stock to the surface of liquid, so that the buoyed mineral and metallic particles of the ore stock are maintained upon the surface of such liquid for a greater length of time than the rock matrix of the ore stock and thereby for such time separated therefrom, substantially as described.

4. The herein-described process for concentrating ore, consisting of producing by heat a vacuumed and expanded condition in the mineral and metallic particles of the ore, of presenting to such ore while in a heated, vacuumed, and expanded condition and by movement and pressure mechanically joining with the mineral and metallic particles thereof particles of buoyant material, of cooling and aerating such buoyed mineral and metallic particles, of obtaining a tremulous movement on the surface of a body of liquid by producing an effervescing condition therein below and at the surface thereof, and of presenting such prepared ore stock to the tremulous surface of such liquid, so that the buoyed mineral and metallic particles of the ore stock are maintained upon such surface for a greater length of time than the rock matrix of the ore stock, and thereby for such time separated therefrom, substantially as described.

5. The herein-described process for concentrating ore, consisting of producing by heat a vacuumed and expanded condition in the mineral and metallic particles of the ore, of presenting to such ore while in a heated, vacuumed, and expanded condition and by movement and pressure mechanically joining with the mineral and metallic particles thereof particles of buoyant material, of cooling and aerating such buoyed mineral and metallic particles, of presenting such prepared ore stock to the surface of liquid so that the buoyed mineral and metallic particles of the ore stock are maintained upon the surface of such liquid for a greater length of time than the rock matrix of the ore stock, and of producing a current of gas moving in relation to the surface of the liquid and in a direction from the place of presentation of the prepared ore stock to the surface thereof, whereby the buoyant mineral and metallic particles of the ore stock are separated from the rock matrix thereof for such time, and particles of the ore stock floating upon the surface of the liquid are moved over and on the surface of such liquid by such current of gas, substantially as described.

6. The herein-described process for concentrating ore, consisting of producing by heat a vacuumed and expanded condition in the mineral and metallic particles of properly-pulverized ore, of presenting to such ore while in a heated, vacuumed, and expanded condition and by movement and pressure mechanically joining with the mineral and metallic particles thereof buoyant material, of cooling and aerating such buoyed mineral and metallic particles, of obtaining a tremulous and wavy movement on the surface of a body or liquid contained in a receptacle having stalling-partitions by producing an effervescing condition in the liquid below and at its surface and a current of gas moving over and on such surface, and of presenting such prepared ore stock to the surface of the liquid, so that the buoyed mineral and metallic particles of ore are maintained on the surface of such liquid for a greater length of time than the rock matrix of the ore stock, and thereby for such time separated therefrom and the particles of ore stock floating on the surface of the liquid moved on and over such surface, substantially as described.

CHARLES B. HEBRON.

Witnesses:
WILLIAM B. ELLIS,
CHARLES T. BROWN

(No Model.) 2 Sheets—Sheet 1

G. ROBSON

SEPARATION OF METALS AND METALLIC COMPOUNDS FROM ORES OR OTHER SUBSTANCES.

No. 575,669. Patented Jan. 19, 1897.

Fig. 1.

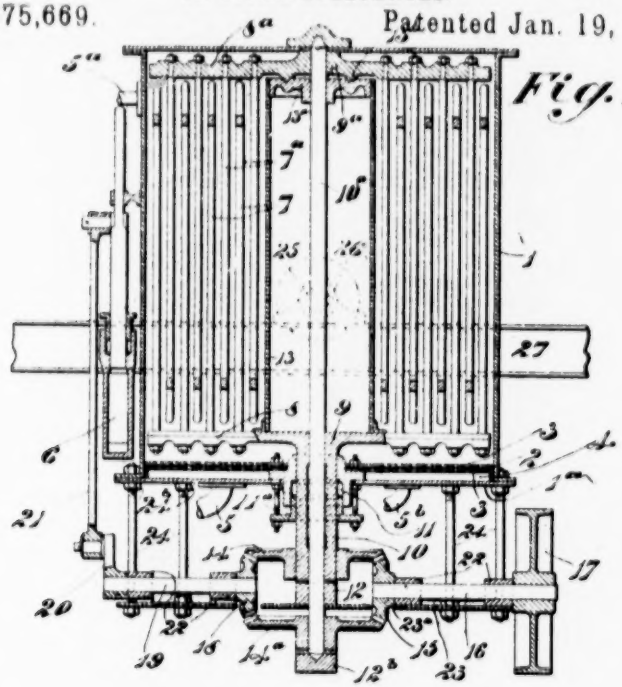
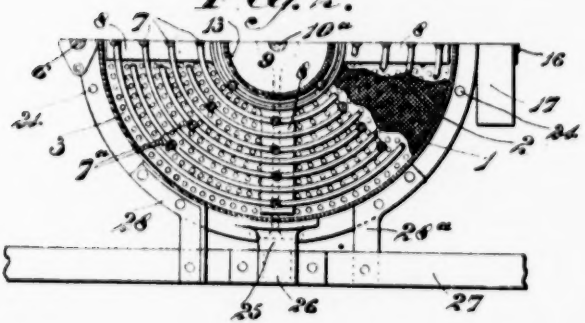


Fig. 2.



Witnesses.
E. C. Duff
Hubert F. Keck

Fig. 3.

Inventor:
George Robson
per O. E. Duff
Attorney

(No Model.) 2 Sheets—Sheet 2

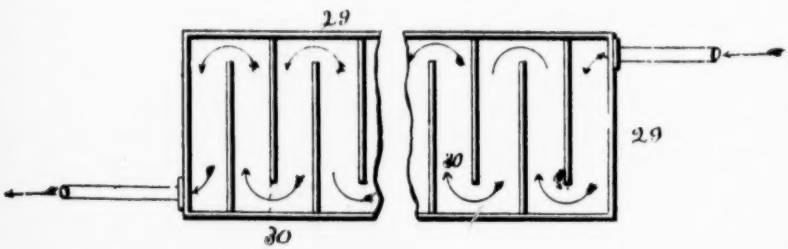
G. ROBSON

SEPARATION OF METALS AND METALLIC COMPOUNDS FROM ORES OR OTHER SUBSTANCES.

No. 575,669 Patented Jan. 19, 1897

1241

Fig. 4



Witnesses:
F. C. Barry
C. E. Duffy

Inventor
Geo Robson
per O. E. Duffy
Attorney

UNITED STATES PATENT OFFICE.

GEORGE ROBSON, OF DOLGELLY, ENGLAND, ASSIGNOR TO HIMSELF, AND SAMUEL CROWDER, OF LONDON, ENGLAND

SEPARATION OF METALS AND METALLIC COMPOUNDS FROM ORES OR OTHER SUBSTANCES.

SPECIFICATION forming part of Letters Patent No. 575,669, dated January 19, 1897.

Application filed July 18, 1894. Serial No. 517,937. (No model.) Patented in England January 8, 1894, No. 427; in Transvaal April 2, 1894, No. 617; in France July 5, 1894, No. 239,819; in Germany November 24, 1894, No. 82,722; in Victoria October 29, 1895, No. 12,628; in New South Wales October 31, 1895, No. 6,163; in South Australia October 31, 1895, No. 3,075, and in New Zealand November 5, 1895, No. 8,035

To all whom it may concern:

Be it known that I, GEORGE ROBSON, a subject of the Queen of Great Britain and Ireland, residing at Llanfachreth, Dolgelly, North Wales, United Kingdom of Great Britain and Ireland, have invented an Improvement in the Separation of Metals and Metallic Compounds from Ores or other Substances, (for which I have obtained Letters Patent in England, No. 427, dated January 8, 1894; in France, No. 239,819, dated July 5, 1894; in Germany, No. 82,722, dated November 24, 1894; in Victoria, No. 12,628, dated October 29, 1895; in New South Wales, No. 6,163, dated October 31, 1895; in South Australia, No. 3,075, dated October 31, 1895; in New Zealand, No. 8,035, dated November 5, 1895, and in Transvaal, No. 617, dated April 2, 1894,) of which the following is a specification.

This invention has for its object to separate and recover, in an economical manner, finely-divided metal and metallic compounds, such as sulfids and metallic oxids present in finely-divided substances, such as crushed ores, slimes, and the refuse matter, such as the tailings, float matter, and the like, carried away by the water used in the washing and dressing of metalliferous ores and earths, as in crushing-machines, buddles, jigging-machines, vanning-machines, and the like. For this purpose the substances containing finely-divided metal or metallic compounds such as referred to, or both, (hereinafter referred to as metallic matter,) are brought into intimate contact with an oily liquid that is of less specific-gravity than water, and is capable of taking up the said finely-divided metallic matter and thus separating it from the substances with which it was previously mixed.

I have found by experiment that a suitable liquid for the purpose mentioned can be obtained by mixing a liquid hydrocarbon, such, for example, as turpentine, petroleum, paraffin, or the like, with a fatty oil such as colza-oil, the proportion of fatty oil in the mixture varying say, for example, from about ten to twenty-five per cent. of the hydrocarbon, according to the nature of the material to be treated. For example, when treating quartz containing gold and iron oxid for the recovery of the gold a smaller quantity, say ten per cent., of fatty oil should be used than when iron oxid is absent, in order that the iron oxid may not be removed with the gold. I prefer to use as the liquid hydrocarbon a mineral oil such as petroleum or paraffin on account of its cheapness. The fatty oil appears to play the principal part in the actual separation of the metallic matter, the liquid hydrocarbon acting the part of a diluent.

In carrying out my invention the finely-divided substances can, in a soft and plastic state, be brought into contact with the mixture of oils (hereinafter referred to as the oily liquid) in various ways. Thus the said substances in a moist or pasty state, due to admixture therewith of a small quantity of water, say from about twenty-five per cent. to thirty-five per cent. of water, may be mixed or agitated with the oily liquid in a suitable vessel in such a manner that the metallic matter present in the resulting mud or mass will be brought into intimate contact with the oily liquid, so as to be taken up thereby and be then carried to the surface of the mass, whence it can be run off, with a portion of the oily liquid, into a suitable settling vessel or separating device wherein the metallic matter is allowed to subside or is separated and from which the oily liquid is withdrawn for reuse.

In the accompanying drawings, Figure 1 is a vertical section, and Fig. 2 a half-sectional plan showing an arrangement of apparatus suitable for thus carrying out my invention. Fig. 3 is a detail view. Fig. 4 is a part plan of a settling vessel.

The apparatus, Figs. 1, 2, and 3, comprises a vessel 1, provided with a false bottom consisting, preferably, of finely perforated or reticulated sheet material 2, held between two stronger and coarsely-perforated plates 3, the space between this false bottom and the true bottom 1ª of the vessel forming a delivery-

chamber 4, that is placed by a pipe 5 in communication with a pump 6 for supplying the oily liquid thereto.

5ª is an exit-pipe for running off oily liquid laden with metallic matter into a separating device.

5ᵇ is a pipe normally closed for draining off the oily liquid remaining in the vessel at the termination of the treatment of a charge of material.

Within the vessel are arranged two series of vertical stirring-rods 7 7ª, arranged to revolve in concentric circles and carried by horizontal arms 8 8ª, extending, respectively, from hubs 9 9ª, fixed to or formed in one, with two rotary shafts 10 10ª extending through the bottom of the vessel. The shaft 10 passes through a stuffing-box 11 and is carried by a step-bearing 12, formed by the central portion of a curved bracket 12ª, (shown separately in Fig. 3,) the ends of which are secured to the bottom of the vessel. The hub 9 of this shaft may advantageously be provided with a centrally-arranged tubular extension 13, through which the shaft 10ª extends and which is closed at the top by a cover 13ª, formed with an annular bearing 13ᵇ, of V shape in cross-section, and adapted to receive a correspondingly-shaped annular ridge on the under side of the hub 9ª and so prevent escape of material at this point. The rotary shaft 10ª extends through the shaft 10 and is carried by a second step-bearing 12ᵇ, formed and arranged similarly to 12.

To the shafts 10 and 10ª are respectively fixed two bevel-wheels 14 14ª, that are in gear with a bevel-wheel 15, that is common to them and which is fixed upon a driving-shaft 16, provided with a driving-wheel 17.

18 is a bevel-wheel in gear with bevel-wheel 14 and fixed upon a shaft 19, having a crank 20, which serves to operate, through a connecting-rod 21, the pump 6, which may be of any suitable kind, such as a single or double acting plunger pump. The bearings 22 of the two shafts 16 and 19 are carried by a plate 23, which is suspended from the bottom of the vessel 1 by bolts 24 and is slotted at 23ª to accommodate the bevel-wheels 15 and 18.

To enable the bottom 1ª to be readily removed for gaining access to the chamber 4, the said bottom may conveniently be secured in place by nuts 24ᵇ on the bolts 24 and the stuffing-box 11 be unprovided with the usual flange at its outer end, so that upon loosening the said nuts and the nuts upon the gland-studs the bottom can be lowered to an extent limited by the stuffing-box gland 11ª. The vessel is provided with trunnions 25, mounted in bearings 26, fixed upon two beams 27, so that it can be partly rotated, when necessary, to discharge its contents, at which time the driving-belt is removed from the driving pulley 17.

28 28ª are two brackets fixed to the vessel and adapted to bear against the upper and lower sides, respectively, of one of the beams 27, to which they are fixed by bolts to hold the vessel steady when the stirring mechanism is in operation.

The exit-pipe 5ª is arranged to deliver the oily liquid escaping from the top of the vessel into a separator having its outlet in connection with the suction of the pump 6, the arrangement being such that oily liquid can be caused to flow continuously through the finely divided and agitated substances in the vessel 1 and then be delivered with metallic matter taken up thereby into the separator, wherein such matter is separated from the oily liquid, which is drawn off by the pump for reuse.

In carrying out the invention the cover 13ª of the vessel 13 is removed, the finely-divided metalliferous substances in the form of a soft plastic mass, produced by previous admixture of water therewith, as set forth, is placed in the vessel, the cover replaced, the stirring-rods 7 7ª set in motion, and oily liquid circulated continuously through the vessel and separator. By the agitation of the plastic mass with the oily liquid the finely-divided metallic matter present therein is brought into intimate contact with the oily liquid, which takes it up and carries it off from the gangue or earthy matter present, which, owing to its admixture with water, forms a soft plastic mass that is of greater specific gravity than the oily mixture and which is not disintegrated by and consequently disseminated through and carried off by the oily liquid. In this way the finely-divided metallic matter is separated from the gangue and floated or carried off by the oily liquid into the separator, where it is allowed to deposit by gravity, the gangue remaining in the form of a soft plastic mass at the bottom of the mixing vessel.

The separating device may conveniently consist of a settler of ordinary construction, consisting of a vessel 29, Fig. 4, provided with divisions or baffles 30, so as to form a zigzag course for the oily liquid, and in which the metallic matter is allowed to separate from the oily liquid by gravity, the oily liquid running off clear for reuse.

I am aware that it has been proposed to recover finely-comminuted metal from ores by the use of oils mixed with acids or salts by mixing the finely-divided ores with oils and acids or salts and afterward washing out the gangue with water, and also of mixing the ores with oils and then washing out the sand or gangue with water containing acid. I disclaim the use of acids or salts and also the method of washing away the gangue with water, both these methods being entirely dissimilar to the method herein described as constituting my invention, according to which I effect the separation of the metallic matter by the mixture of oils alone, using such mixture to wash out the metallic matter and avoiding as far as possible the presence of water much in excess of the quantity hereinbefore mentioned, as I find an excess of water

prevents the successful carrying out of my invention.

It has been found that the oily mixture has an affinity or cohesion with the metallic particles greatly exceeding that for the non-metallic particles, so that when motion is imparted to the oil the traction of the oil, due to the aforesaid cohesion, is sufficient to overcome the gravital tendency of the metallic particles, while its cohesion for the non-metallic particles is insufficient to overcome the gravital tendency of said non-metallic particles. It follows that when such motion has been imparted to the oil the traction on the metallic particles is sufficient to carry such particles up while the non-metallic particles remain behind, a separation of the two being thus effected, the metallic particles being afterward separated from the oily mixture.

What I claim is—

1. The herein-described mode of separating and recovering finely-divided metal and metallic compounds from finely-divided substances, which consists in intimately and thoroughly mixing said substances with a diluent liquid containing a fatty substance so that the metallic portions are taken up by the fatty substance then removing the oily liquid with metallic matter from the said finely-divided substances and then separating the metallic matter from said oily liquid, substantially as herein described.

2. The method of recovering metals and metallic compounds from finely-divided substances, which consists in thoroughly and mechanically agitating and mixing a fatty oil with said substances while the same are in a moist or plastic state due to admixture of water therewith, then drawing off the fatty oil carry the metal particles, and metallic compounds from said substances, and then separating the metals and metallic compounds from the oil, substantially as described.

3. The herein-described mode of recovering metals and metallic compounds from finely-divided substances in a moist state, which consists in passing oil through the mass of finely-divided material so that the oil floats off the metallic portions against the force of gravity, and removing the oil carrying said metallic particles and separating the metallic portions therefrom, substantially as described.

4. The herein-described method of separating and recovering finely-divided metal and metallic compounds from finely-divided substances which consists in forming said finely-divided substances into a moist or pasty mass by admixture therewith of water, floating off finely-divided metallic compounds from said mass by agitating the same with an oily liquid, drawing off the oily liquid, and separating therefrom the metallic matter carried off thereby, substantially as described.

5. The herein-described method of washing out metals and metallic compounds from finely-divided substances, which consists in causing an oily liquid to flow in a practically continuous stream through the said substances while the same are in a stirred or agitated state, separating the metallic matter from the oily liquid by gravity after it has been removed from the said substances, and afterward again bringing the oily liquid into contact with the said substances for reuse, substantially as herein described.

6. The combination of the horizontal supporting-beams, the closed separating vessel having the inlet and outlet pipes and the driving-gear at its lower end, said vessel having the lateral trunnions journaled in said beams and the lateral arms 28 and 28^a above and below the planes of the beams as and for the purposes described.

7. The combination of the outer casing, the vertical shaft passing therethrough and at one end of the casing, having the disk provided with stirring-arms extending longitudinally of the casing, a sleeve on said shaft and turning oppositely thereto, a disk in the casing or the sleeve having the stirring-arms extending longitudinally of the shaft and between the first-mentioned stirrer-arms, brackets at the lower end of the casing having bearings for the lower ends of the sleeve and shaft, and gears on the sleeve and shaft provided with means for driving them in opposite directions, substantially as described.

8. For separating and recovering metallic matter from finely-divided substances containing the same, apparatus comprising a pivoted vessel having a perforated or reticulated false bottom and inlet and outlet passages for oily liquid, stirrers arranged within said vessel, a pump carried by said vessel and adapted to cause oily liquid to flow therethrough and mechanism carried by said vessel for driving said stirrers and pumps substantially as herein described.

9. In a separator, the combination of the cylindrical casing, the central longitudinal shaft therein, the disk on the shaft at one end of the casing having the stirrers, the sleeve turnable on the shaft, the disk on said sleeve in the opposite end of the casing having the stirrers extending between and parallel with the opposite stirrers, the central closed longitudinal cylinder 15, between and engaging said disks, and gearing rotating the sleeve and shaft in opposite directions, substantially as described.

In testimony whereof I have signed my name to this specification in the presence of two subscribing witnesses.

GEORGE ROBSON

Witnesses:
PERCY ERNA HOCKS,
EDMUND S. SNEWIN.

No. 763,259. PATENTED JUNE 21, 1904.

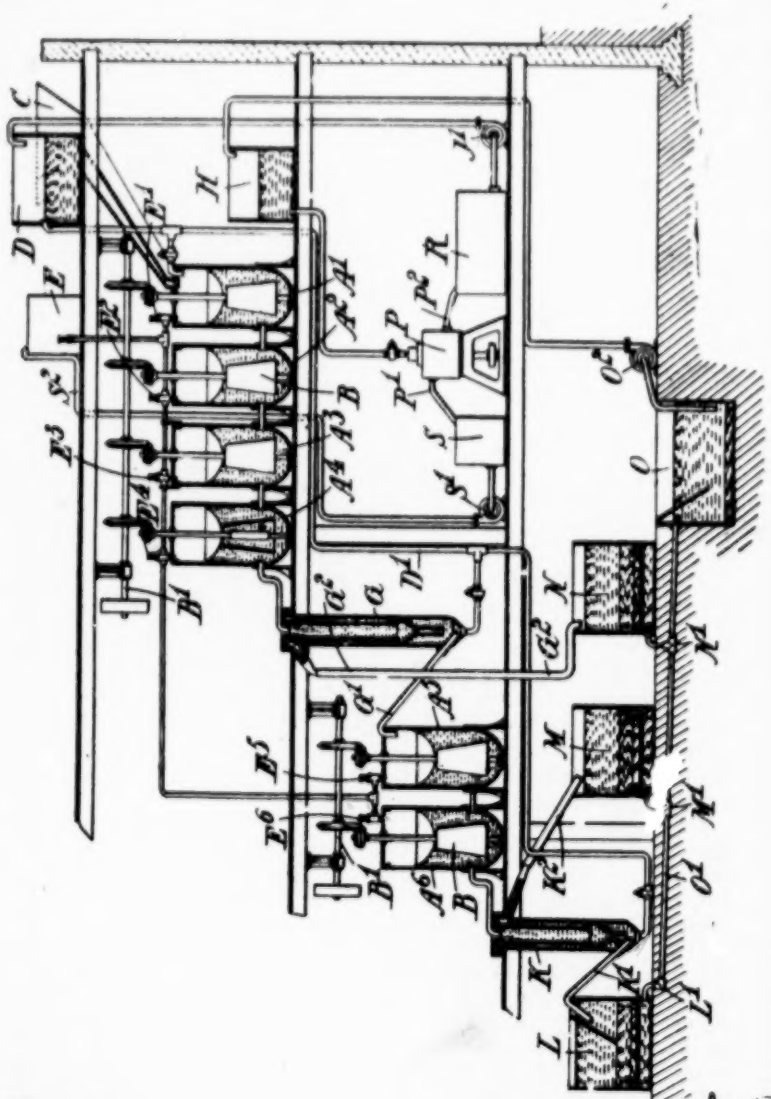
A. E. CATTERMOLE.

CLASSIFICATION OF THE METALLIC CONSTITUENTS OF ORES.

1246

APPLICATION FILED SEPT. 29, 1903.

NO MODEL.



Witnesses:

Inventor

Arthur E. Cattermole

1247

No. 763,259.

Patented June 21, 1904.

United States Patent Office.

Arthur Edward Cattermole, of London, England.

Classification of the Metallic Constituents of Ores.

Specification Forming Part of Letters Patent No. 763,259, Dated June 21, 1904.

Application filed September 29, 1903. Serial No. 175,060.

(No Specimens.)

To all whom it may concern:

Be it known that I, Arthur Edward Cattermole, a subject of the King of England, residing at London, England, have invented certain new and useful Improvements in the Classification of the Metallic Constituents of Ores, of which the following is a specification.

The present invention relates to the classification of the metalliferous constituents of ores which have been separated from gangue by oil or similar matter, such as certain wood or coal tar products, hereinafter referred to as "oil," in which term I also include the emulsifying agent is present with the oil.

The invention consists in fractionally removing the different constituents from the agglomerated masses by freeing the constituents in turn from the oil, and thus obtaining them in a separable condition by the use of emulsifying agents of varying strength and activity, preferably in conjunction with an alkali.

In carrying out the process the metalliferous mineral matter agglomerated by oil is mixed and agitated with a solution of an emulsifying agent, such as a soluble soap—alkaline oleate, for example—to which a certain proportion of soluble alkali, preferably caustic potash or soda, has been added.

It is found that minerals vary in their affinity for oil employed in the above manner, and thus by treating the oily masses or granules in the first place with an alkaline emulsifying solution of a certain strength the mineral of least affinity can be separated therefrom and by increasing the strength or modifying the proportions of the breaking-down solution step by step the various metalliferous constituents may be thrown out in the order of their increasing affinities. Taking for example, an ore containing siliceous gangue, rosin-blende, copper pyrites, and galena, the ore is first treated with oil or emulsified oil for the granulation of the metalliferous mineral. The oil is preferably one such, for example, as a hydrocarbon oil which is not too readily emulsified and which gives a wide range of strength

in the solutions required for breaking down the granules. The compound granules separated from the siliceous gangue and liquor are drained and run into the first classifying apparatus, where they are agitated with a solution, which may have, say, a strength of three-fourths of one per cent. soap (when this is the emulsifying agent employed) and of three-fourths of one per cent. alkali, by which the rosin-blende is dropped out. The granules remaining freed from blende and liquor are then passed onto a second similar apparatus in which a solution of a strength of, say, one and one-half per cent. soap, one and one-half per cent. alkali is used. Here the copper pyrites is freed and subsequently removed, the galena remaining still granulated. The oil may finally be recovered from these granules by the use of a solution of suitable—i. e., sufficient—strength of alkali and emulsifying agent, and its separation from the mineral may be promoted by attrition.

The strength of the breaking-down solutions required and the relative proportions of their constituents depend mainly upon the following conditions—that is to say, upon the state of fineness of the ore treated, the relative proportions of the contained minerals one to another, their physical condition and chemical composition, the nature of the oil, emulsifying agent, and alkali used.

The example above given indicates for an ore such as is there supposed to be under treatment and for the oil and emulsifying agent, mentioned in what proportions these agents should be employed. In the case of another ore and of other reagents the proportions may need to be readjusted, and for the purpose of such readjustment the following rules may be laid down. The finer the ore the more compact and cohesive are the granules formed from it, other things being equal, and therefore stronger breaking-down solution will be required with a finely ground ore than with one coarsely ground. With granules where minerals, such as galena, which offer great resistance to the breaking-down action of the solution preponderate the breaking-down solution should of course be stronger
1218 or more active than in the alternative case, (where mineral such as rosin-blende, which offers less resistance to the breaking-down solution preponderates.)

In considering the chemical composition of the minerals it is of course necessary to bear in mind that a constituent mineral—say, for example, zinc-blende—may contain impurities or other metalliferous constituents (such as iron sulfid) which will materially affect their resistance to the breaking-down action of the solution, in the case supposed increasing such resistance.

With regard to the nature of the oil. With the animal or vegetable oils or readily-emulsified oils the breaking down is comparatively rapid and may be too rapid for conveniently carrying out this process. With heavy residuum oils and other heavy hydrocarbon oils, which are emulsified with difficulty, the breaking down is comparatively difficult and slow. Oils may be blended for the purpose of obtaining a mixture which suits the requirements of any particular mineral mixture which may be under treatment. The breaking down is effected most advantageously with emulsifying agents

and alkali which are readily soluble. Bearing these principles in mind, the operator will always be able to determine by observations made in the course of working, or, if he so prefers, by a few simple preliminary tests, under what conditions this process can be worked to the best advantage.

In the upcurrent or other separating device for removing the feed mineral from the granules remaining solution of the same strength as that used in "breaking down" may be employed, or it may be somewhat weakened by dilution, so long as the reagglomeration of the separated mineral does not take place.

The more or less emulsified oil removed from the granules separates out as a "cream" or concentrated emulsion from the breaking-down solution employed, and the separation of such oil for reuse in the various stages and recovery of oil-depleted solution for reuse in the breaking-down stage may be hastened by the employment of mechanical separators. Since oil is being removed in each breaking-down stage, it is generally preferable to start with the compound mineral granules in a rather soft or pasty condition by the use of a sufficiency of oil in the granulating stage, or, if necessary, the granules from one stage if reduced too small by removal of oil for ready separation may be again treated with oil or oil emulsion, or oil or oil emulsion may be added to the breaking-down solutions in the requisite small amounts to keep the granules of proper size and consistency to be dealt with in the separating devices in use. The presence of a certain amount of oil in the solutions assists separation by preventing the too ready breaking down of the granules.

The separated minerals may be drained or treated in centrifugal or other mechanical solution-extractors for the closer recovery of solution and drying of the product.

The accompanying drawing is a diagram illustrating in sectional view one method of carrying out the process according to this invention as applied to a mixed sulfid ore—Broken Hill ore, for example—consisting of galena and blende.

A series of connected mixing vessels A A^3 A^4 A^5 A^6 are provided with stirrers B, rotated from driving-shafts B^1. The oily granulated mixture of galena and black blende freed from the gangue from the hopper C and breaking-down solution, which may have a strength of one-half of one per cent. alkaline oleate and one and one-half per cent. caustic alkali, from a tank D are introduced into the first vessel A^1, and the oil or emulsion needed to keep the granules of suitable size and consistency is fed as required from the tank E through pipes and regulating-taps E^1 E^2 E^3 to the various vessels. The mixture is vigorously agitated to break down the mixed granules and liberate the blende. After agitating to a certain extent (in four communicating vessels, as illustrated, for example,) the mixture is passed into an upcurrent classifier G, which is supplied with solution from the tank D through a pipe D^1. The partly-broken-down granules and the heavier particles of liberated blende are discharged through a pipe G into the vessel A^1, while the lighter particles of blende are carried away by the upward current and discharged through outlet-pipe G^2 to the tank N, provided with a filter-bottom for the draining

of the product. The solution is allowed to run by the pipes N^1 and O^1 into a tank O, from which the solution may be returned by the pump O^2 to the tank H. The granules and coarser blende are subjected to further agitation in the vessels A^5 A^6, where the separation of the blende is completed, and are then passed into a second classifier K, from which the galena granules are removed at the bottom by the pipe K^1 into the tank L, while the blende is discharged from the upper pipe K^2 into the tank M. Like N the tanks L M are provided with a filter-bottom, and the solution that drains away is led by the pipes L^1 M^1 and pipe O^1 into the tank O for pumping up to the tank H. The solution thus returned to this tank contains the oil removed from the granules and is thence run into a centrifugal separator P, whence the oil escapes through a pipe P^1 to a tank S, while the solution, deprived more or less completely of oil or oil emulsion, runs into a tank R and is thence returned by the pump J^1 to the feed-tank D for reuse. The separated oil or oil emulsion in the tank S is returned by the pump S^1 through a pipe S^2 to the oil or emulsion tank E. This apparatus is illustrated only as one convenient
1249 method of carrying out this invention and it is to be understood that its nature and arrangement can be considerably varied.

The process, it will be seen, comprises two steps which are essentially distinct—first, the removal of certain constituents from the agglomerated masses or granules, and, second, the separation of the material so removed from the remaining granules. In the apparatus described and illustrated in the accompanying drawing, I have provided for the carrying out of these two stages of the process in separate vessels, (mixers and separators, respectively;) but it will be readily understood that the apparatus and process can, if desired, be so modified that all the operations may be carried on in a single vessel, and similarly the various parts of the apparatus may be modified in a great many ways to suit special conditions of working.

In some cases, as when one of the mineral constituents is small in amount, particularly when among the last to be separated, it may be increased up to the required point for ready separation by incorporating the requisite amount with the initial mixed granules or by addition to the product in the apparatus in which the breaking-down is effected. A certain amount of already-separated mineral may be returned for this purpose, or where, owing to the absence of sufficient fine or slime material weakly-coherent granules breaking down too readily are obtained, such fine mineral may be added, as described, to render such granules more coherent and resistant. In other cases with the same object in view it may be advantageous to subject the granulated mixed mineral to grinding action to further reduce the size of the constituent mineral particles without destroying the agglomeration before breaking down and separation of the constituents.

When minerals granulated with some tarry products are treated, an alkaline breaking-down solution with an emulsifying agent of analogous nature may with advantage be employed. For example, when granulated with wood-tar an alkaline solution of the tar of

suitable proportions and strength is the most suitable liquor to be employed for breaking down and separation of the minerals.

What I claim as my invention, and desire to secure by Letters Patent, is—

1. The herein-described process of classifying metalliferous minerals agglomerated by oil which consists in successively agitating the agglomerated mineral with emulsifying agents of varying strength progressively to free the several minerals in succession.

2. The herein-described process of classifying metalliferous minerals agglomerated by oil which consists in successively agitating the agglomerated mineral with emulsifying agents of varying strength progressively to free the several minerals in succession separating out each mineral in turn by a separating device and adding oil in the requisite small amounts to keep the granules of proper size and consisteney.

3. The herein-described process of classifying metalliferous minerals agglomerated by oil which consists in successively agitating the agglomerated mineral with solution of soap and caustic alkali of varying strength progressively to free the several minerals in succession.

4. The herein-described process of classifying metalliferous minerals agglomerated by oil which consists in succesively agitating the agglomerated mineral with solutions of soap and caustic alkali of varying strength progressively to free the several minerals in succession and separating out each mineral in turn by an upward current.

5. The herein-described process of classifying metalliferous minerals agglomerated by oil which consists in successively agitating the agglomerated mineral with solutions of soap and caustic alkali of varying strength progressively to free the several minerals in succession separating out each mineral in turn by an upward current and adding oil in the requisite small amounts to keep the granules of proper size and consistency.

In testimony whereof I have signed my name to this specification in the presence of two subscribing witnesses.

ARTHUR EDWARD CATTERMOLE.

Witnesses:

HASOP WADE.

HARRY S. GRIDGE.

No. 763,260. PATENTED JUNE 21, 1904.

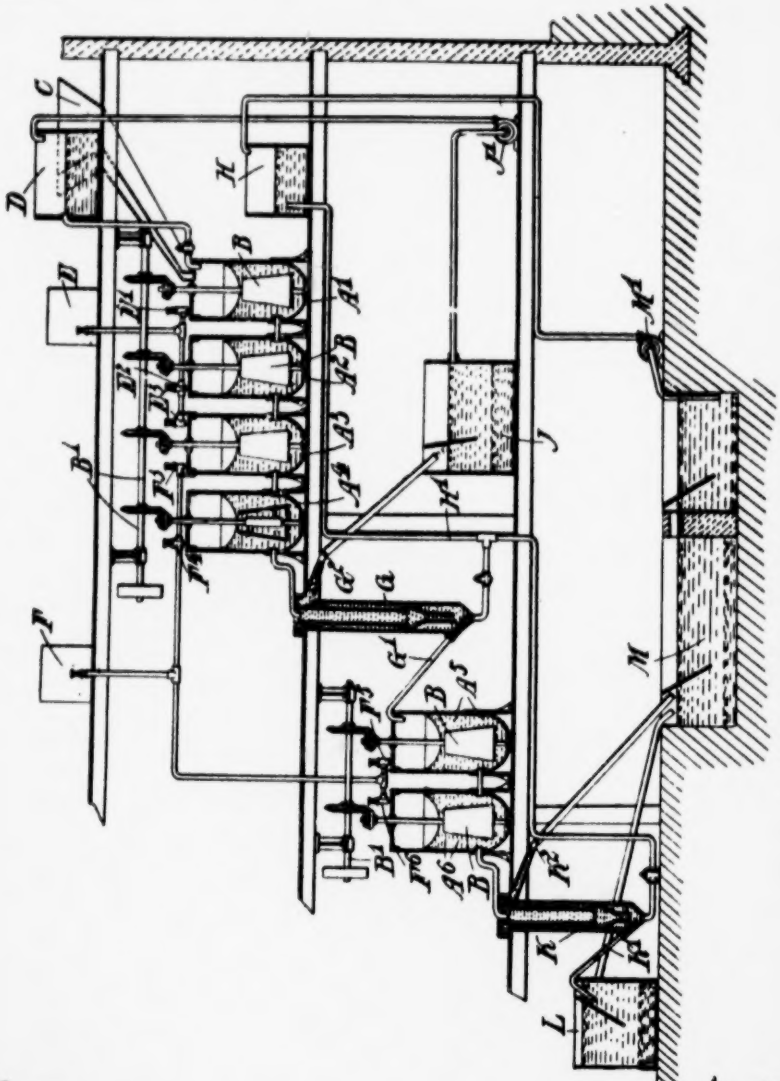
A. E. CATTERMOLE.

SEPARATION OF THE METALLIC CONSTITUENTS OF ORES FROM GANGUE.

APPLICATION FILED JAN. 2, 1904.

NO MODEL.

1250



Witnesses:
Harold Pond
Jno. R. Adams

Inventor:
Arthur E. Cattermole
By Knight Bros.
Attorneys

No. 763,260. Patented June 21, 1904.

UNITED STATES PATENT OFFICE.

ARTHUR EDWARD CATTERMOLE, OF HIGHGATE, LONDON, ENGLAND.

SEPARATION OF THE METALLIC CONSTITUENTS OF ORES FROM GANGUE.

SPECIFICATION forming part of Letters Patent No. 763,260, dated June 21, 1904.

Original application filed September 28, 1903, Serial No. 174,947. Divided and this application filed January 2, 1904. Serial No. 187,599. (No specimens.)

To all whom it may concern:

Be it known that I, ARTHUR EDWARD CATTERMOLE, a subject of the King of England, residing at Highgate, London, England, have invented certain new and useful Improvements in the Separation of the Metallic Constituents of Ores from Gangue, of which the following is a specification.

This application is a division of my application filed September 28, 1903, Serial No. 174,947.

The present invention relates to improvements in the separation of the metalliferous constituents of ores and the like from gangue by means of the selective action of oils and certain tar products or similar compounds (all hereinafter referred to as "oil") on metallic or metalliferous matter.

The invention depends upon the application of the following facts: First, when a mixture of powdered metalliferous matter and gangue is treated with oil suspended in water—that is to say, in emulsion—the oil has a more or less selective action and will coat the particles of metalliferous matter in preference to the particles of gangue, while the particles of gangue will be wetted by the water; second, if the water be made alkaline and an emulsifying agent, such as soap, be present, the selective action of the oil will be rendered more marked and decisive; third, if the proportion of oil is kept within reasonably low limits (differing in different cases, according to the nature of the mineral to be treated and the consistency and nature of the oil) and if the mixture of water, oil, metalliferous particles, and gangue be thoroughly agitated, the metalliferous particles which have become coated with oil will adhere together and form granules, which granules, partly by reason of gravity or partly on account of their bulk as compared with the individual grains of gangue, will offer ready means for separation in an upcurrent-separator, a jig, or other similar appliance. This action is facilitated if the oil before addition to the liquor is brought into the condition of an emulsion in water containing a small percentage of free soap.

In some cases the pulp may contain mineral acid. Alkali must then be added in sufficient quantity to neutralize the acid and to leave some alkaline soap undecomposed—that is, free.

These facts are utilized for the purpose of separating the metalliferous constituents from the gangue of the ore in the following manner: In a suitable apparatus, an example of which will be hereinafter described, the ground or pulped ore is caused to be violently agitated, as by a revolving stirrer, in a mixture of water and oil, the liquor containing an alkaline emulsifying agent. As the agitation proceeds the particles of metalliferous matter agglomerate together and may be observed in the form of granules, the size of which will depend, among other things, upon the percentage of oil used. This granulation of the metalliferous constituents of the ore affords the means by which at a later stage of the process it is possible to separate the metalliferous material from the gangue, as will be hereinafter particularly described. In practice a continuous process is used—that is to say, water, ground ore, or pulp and oil, preferably emulsified, are continuously fed into a series of vessels and the products of the agitation are continuously fed into an upcurrent-separator or jig or similar device which in the case of the upcurrent-separator separates the metalliferous granules from the gangue by allowing them to fall to the bottom of the vessel and to be carried away by a downward stream, while the particles of gangue are carried away by an upward stream.

The accompanying drawing is a diagram illustrating in sectional view one means of carrying out the process according to this invention.

A series of connected mixing vessels $A' A^2 A^3 A^4 A^5 A^6$ are provided with stirrers B, rotated from driving-shafts B'. Crushed ore from a hopper C and circuit-water from a tank D are introduced into the first vessels A', and oil or emulsion is fed from a tank E, through pipes $E' E^2 E^3$, to the various vessels. The mixture is vigorously agitated to break up and emulsify the oil and it in-

timate contact of the divided oil with the metalliferous mineral particles and of the oiled particles with each other. An alkaline emulsifying agent, such as soap, is introduced into one or more of the vessels from a tank F, having discharge-pipes F' F^2 F^3 F^4. It is found under these conditions that the metalliferous mineral particles abstract the oil and become coated with a thin oily film which is insufficient to materially lessen their specific gravity and that under agitation such slightly-oiled particles adhere, nucleate, and agglomerate into small more or less rounded masses or granules disseminated throughout the mass of gangue, which remains free and practically devoid of oil. After agitation to a certain extent (in four vessels, as illustrated, for example) the mixture is passed into an upcurrent-classifier G, which is supplied with a stream of circuit-water from a tank H through a pipe H'. As the granules remain specifically heavier than the gangue or can by suitably adjusting the amount of oil and the agitation be obtained of a size larger than that of the gangue particles, the granules, with a certain amount of heavy sands, sink to the bottom and are discharged through a pipe G' into vessel A^5, while the lighter sands are carried away by the upward current and discharged through outlet G^2 to a light-sands tank J, from which the circuit-water may be returned by a pump J' to the feed-tank D for reuse. In order to separate the granules from the heavy sands, the mixture is subjected to further agitation in the vessels A^5 A^6 and is then passed into a second classifier K, from which the granules are removed at the bottom by the pipe K' into the metalliferous-mineral tank L, while the heavy sands are discharged from the upper pipe K^2 into a heavy-sands tank M. The circuit-water from the tanks L and M is returned by a pump N' to the feed-water tank H. This apparatus is illustrated only as one convenient method of carrying out this invention, and it is to be understood that its nature and arrangement can be considerably varied.

The water throughout the circuit is alkaline and contains a suitable proportion of soap or other emulsifying agent. The agitation vessels may be separate, with arrangements for charging and discharging, the charging with pulp and the addition of oil or emulsified oil and the agitation and discharge successively in the series of vessels being so timed that the output of treated ore is kept continuous and constant. The classifiers used may be jigs, shaking-tables, or the like or sizing apparatus whereby the comparatively larger mineral granules may be separated from the finer gangue, and one or more classifiers may be employed.

The proportion of oil used depends upon its viscosity, the fineness of the ore, and other factors, and the consistency and size of the mineral granules desired. The more oil used the larger, softer, and less numerous the granules. With, say, ten per cent. of oil to the weight of metalliferous mineral a few pasty masses of oil agglomerated metalliferous mineral matter will generally result. Oil in excess of this may cause all the granules to coalesce into one soft mass. Usually an amount of oil varying from four per cent. to six per cent. of the weight of metalliferous mineral matter present in the ore yields granules of suitable size, consistency, and specific gravity for ready separation from the gangue in the upcurrent or other apparatus used for classification

The amount of emulsifying agent, if used to form the oil-emulsion, depends upon the viscosity and nature of the oil. When soap is employed, an amount varying from three per cent. to five per cent. of the weight of oil usually suffices, this being dissolved in, say, ten times its weight of water. For emulsification a low alkalinity of the emulsifying agent is generally best.

The oil used may be animal, vegetable, or mineral oil, or mixtures of these, or such coal or wood tar products or other substances which exercise, like oils, a preferential physical affinity for metallic mineral matter as distinguished from gangue.

The emulsifying agent may be any substance capable of holding the oil in a fine state of division in suspension in water without acting on the mineral matter or preventing the action of the oil—for example, soap, alkaline cresylates, or other substances solutions of which in water froth on agitation. The emulsifying agent appears to have a decided effect in bringing about the granulation as described. In some cases, as with wood-tar and some coal-tar products, these when agitated in weak alkaline solutions provide their own emulsifying agents, soluble resinates, cresylates, &c., being thereby formed, which emulsify the bulk of the tar or product.

Emulsification in some cases, as with the heavier residuum oils or tars, may be assisted by first mixing therewith a small amount of fatty oil or fatty acid. Preferably one emulsifying agent is employed throughout the process.

In order to recover the oil from the granules after their separation from the gangue, they may be agitated with the emulsifying agent in a stronger or more active condition or proportion than was used in the emulsification of the oils initially, and the action of this emulsifying agent in stripping the oil from the metalliferous mineral particles may be aided by attrition. The strengthening of the emulsifying agent may be effected by increasing the proportion of the agent or of the alkaline base in solution, or both, the percentage strength of the solution needed depending upon the oil used and the nature of the metalliferous mineral matter with which it is

associated. Usually if oleic soap is employed and caustic potash amounts varying from one-quarter of one per cent. to three per cent. or four per cent. of one or the other in solution suffices, the less readily emulsified oils, as the residuum oils, requiring the larger amounts. The removed oil is obtained as a dilute emulsion, which on standing some time separates. The "cream" or concentrated emulsion may then be used for making fresh emulsion for treating fresh ore. To hasten this separation of cream, mechanical devices may be employed.

Generally with wet crushed ore removal of the bulk of the water for reuse in the mill is necessary. In such case the pulp is settled and the wet ore only fed into the agitators, emulsifying agent of suitable strength being added to thin them. The circuit of such liquids can thus be kept distinct from that of the mill-water, suitable arrangements being made for settling the mineral-depleted sands and slime and for addition of emulsifying agent and fresh water as required from time to time.

In certain cases, as where but little mineral is present in the ore, to increase the nucleating or granulating factor pulverized mineral matter obtained in a previous operation or other matter having an affinity for oil from a different source may be introduced into the ore, or a portion of already granulated and separated mineral matter may be returned to maintain the necessary amount of mineral in the ore under treatment.

In carrying out the process the ore may be roughly sized into two or more parts, which are then treated separately. With certain ores it may be preferable to use in some stages of the process a rolling form of agitation, as in cylinders or barrels, to obtain good granulation of the mineral.

It is preferable to use circuit-waters of varying degree of alkalinity, according to the nature of the mineral being treated, provided always that about one-half of one per cent. of soap or other emulsifying agent is present.

It is found advisable to keep the amount of free alkali low in proportion to the free soap present when such is the emulsifying agent used. Thus in one example 0.25 per cent. of free soap with 0.025 per cent. of free alkali was sufficient to keep calcite free from oil, 0.3 per cent. free soap and 0.03 per cent. free alkali kept quartz free from oil, while rather stronger solutions—as, for instance, 0.5 per cent. free soap and 0.05 per cent. free alkali—prevented garnet from becoming oil-coated. These figures refer to cases where a light oil was used—namely, paraffin. When the free soap was increased to about one per cent. or when the free alkali was increased to about one-fourth of one per cent., difficulty was found in agglomerating certain metalliferous substances, such as rosin-blende and iron or copper pyrites. Care must therefore be taken that neither the soap nor the alkali is in excess of that required for preventing agglomeration of the gangue.

I am aware that the selective action of oils and the like on metallic matter has been made the basis of previous processes for separating the metalliferous constituents of ores from gangue. For example, oil has been used to float off metalliferous mineral from ore-pulp, and its use has also been proposed to form a pasty mass of crushed ore from which the gangue could afterward be washed out by means of water, and I do not claim the employment of oil in any such manner.

What I claim as my invention, and desire to secure by Letters Patent, is—

1. The herein-described process of separating metalliferous matter from gangue, which consists in agitating a mixture of powdered ore and water with oil in emulsion in water containing an alkaline emulsifying agent, so as to agglomerate the oil-coated particles into granules, and subjecting the mixture to classification to remove the small non-coated particles from the granules.

2. The herein-described process of separating metalliferous matter from gangue, which consists in agitating a mixture of powdered ore and water with oil in emulsion in water containing an alkaline emulsifying agent, so as to agglomerate the oil-coated particles into granules, and subjecting the mixture to upcurrent classification to remove the small non-coated particles from the granules.

3. The herein-described process of separating metalliferous matter from gangue, which consists in forming granules by agitating a mixture of powdered ore and water with oil in emulsion in water containing an alkaline emulsifying agent, separating out the light sands, and thereafter further agitating the pulp to increase the size of the granules and separating out the heavy sands from the granules.

4. The herein-described process of separating metalliferous matter from gangue, which consists in agitating a mixture of powdered ore and water with oil in emulsion in water containing an alkaline emulsifying agent, adding particles of material having an affinity for oil to assist in the formation of granules of oil-coated particles, and subjecting the mixture to classification to remove the small non-coated particles from the granules.

In testimony whereof I have signed my name to this specification in the presence of two subscribing witnesses.

ARTHUR EDWARD CATTERMOLE.

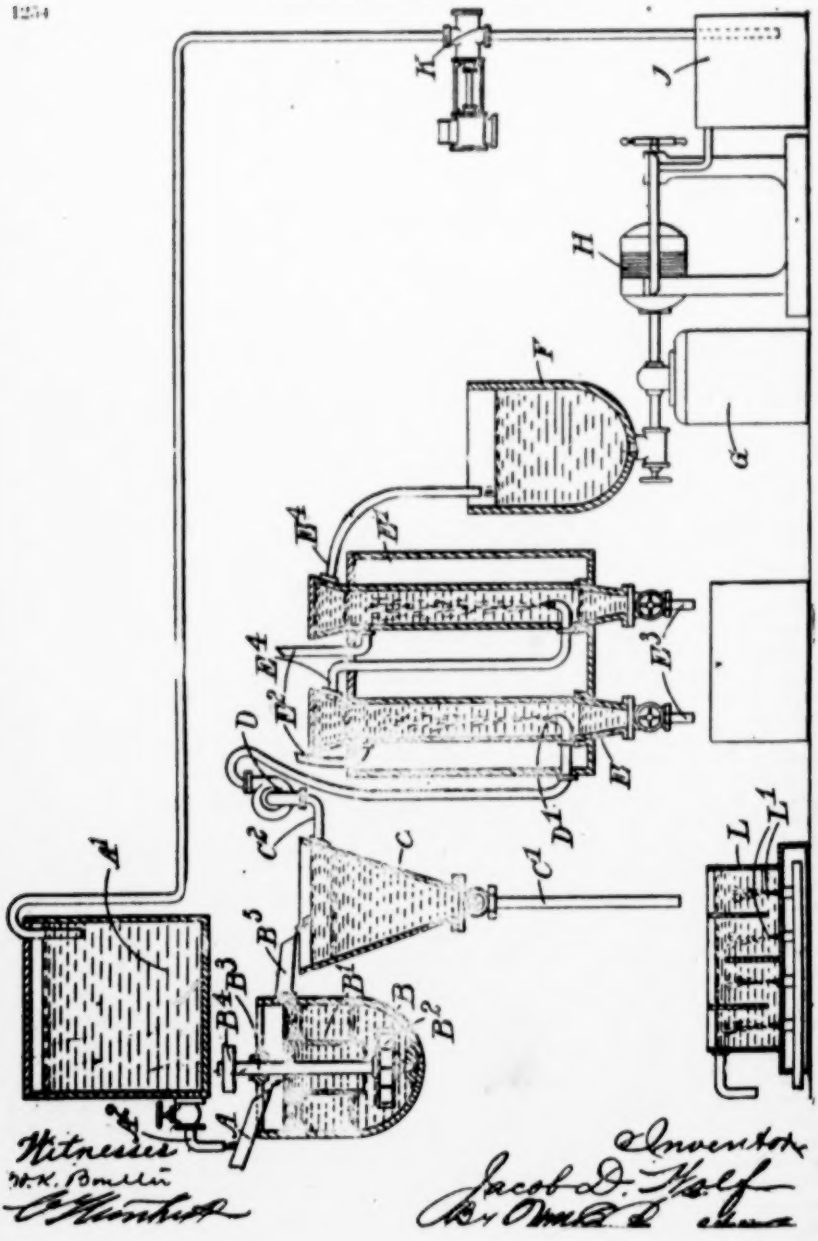
Witnesses.
CHRISTOPHER BARNETT,
WALTER J. SKERTEN.

No. 787,814 PATENTED APR. 18, 1905.

J. D. WOLF.

SEPARATION OF METALS FROM THEIR ORES.

APPLICATION FILED MAY 22, 1903.



No. 787,814. Patented April 18, 1905.

UNITED STATES PATENT OFFICE.

JACOB DAVID WOLF OF LONDON, ENGLAND.

SEPARATION OF METALS FROM THEIR ORES.

SPECIFICATION forming part of Letters Patent No. 787,814, dated April 18, 1905.

Application filed May 22, 1903. Serial No. 158,346.

To all whom it may concern:

Be it known that I, JACOB DAVID WOLF, a citizen of the United States, residing at London, England, have invented certain new and useful Improvements in the Separation of Metals from Their Ores, of which the following is a specification.

The present invention relates to improvements in obtaining metals from their ores, the object being to separate the valuable and metallic-mineral constituents of an ore from its gangue by the use of oil or grease, particularly oil or grease which has been treated with chlorid of sulfur.

According to this invention the ore-pulps are agitated with oil, preferably mineral oil mixed with viscous animal or vegetable oil and treated with chlorid of sulfur, until the oil has taken up all the metallic-mineral contents with some gangue. The mineral-bearing oil is separated from the pulps, and suspended particles of gangue are removed from the oil by passing it through warm water, the metallic minerals being thereafter separated out from the oil, which can be used again. At the same time oil is recovered from the waste pulps by blowing air through them.

In order to increase the viscosity of certain mineral oils, a small proportion—say five per cent.—of animal oil, such as lard-oil, may be added before sulfo-chlorinating. Vegetable oils—such as rape, castor, or linseed oil—act in a similar manner. With pulps having a large proportion of mineral, as in the case of copper, lead, or zinc ores, the prepared oil should be made thick and viscous to produce the necessary power of flotation; but with pulps in which the percentage of mineral is small, as with gold ores, the oil need not be thickened to the maximum extent. In the same way if the particles of mineral are coarse the oil should be specially viscous, while with fine particles the oil may be relatively thinner.

The accompanying drawing is a diagrammatic sectional view of apparatus suitable for use in carrying out this process.

In the following description it is assumed that the oil is treated with chlorid of sulfur; but it is to be understood that the same process and apparatus would apply to other suitable but untreated oils.

The ore mixed with water is crushed into a pulp and is introduced by a launder A into a mixer B, the oil, preferably treated with chlorid of sulfur, being simultaneously run in from the tank A' through the pipe A². The mixing vessel B has a vertical hollow cylinder B' fixed in the middle of it, and below the cylinder is a turbine-wheel B² on a vertical shaft B³, rotatable through the pulley B⁴. The mixture of oil and pulps passes into the hollow cylinder B', and the rotation of the turbine-wheel B² causes a rapid circulation of the mixture downward within the cylinder and upward between the cylinder and the vessel B. The liquid is continuously discharged from the mixer through the pipe B⁵ and passes into a separating-tank or spitzkasten C. Here the sulfo-chlorinated oil adhering to the mineral of the ore floats, while the gangue remaining in admixture with the water sinks and is removed by the waste-pipe C'. The mineral-bearing oil passes off from the surface through the conduit C². The mixture is next forced—for example, by means of a rotary pump D—in at the bottom of a vertical cylindrical vessel E, containing warm water and surrounded by a steam or hot-water jacket E'. The vessel is provided with a water-inlet pipe E² and a waste-outlet E³ at the bottom, and an oil-outlet E⁴ is also provided near the top of the vessel. The oil mixture carrying particles of gangue in suspension is passed into the vessel E, preferably through a perforated inlet D', to break the oil into thin streams or globules, which rise through the warm water and drop out the gangue in their upward course on account of the decrease in viscosity. If desired, two or more of these vessels may be used in series, the mineral-bearing oil being removed from the surface of each vessel. By the means thus provided for eliminating gangue it is possible to treat ores with such a degree of agitation that the whole of the mineral contents are taken up by the oil, accompanied, however, by a not inconsiderable proportion of gangue; but as practically all this gangue is removable from the oil by a

sufficient treatment with hot water much cleaner and sharper concentrates can be obtained than would be the case under any circumstances without such washing. The oil carrying practically only the values is next passed into a receiver F, from which it is forced, by means of a pneumatic forcing apparatus G, into a filter-press H, which may be of any suitable form—for example, of the type now largely used in the treatment of lard, tallow, and similar oils by fullers' earth. The separated oil is received in a tank J and is returned, by means of a pump K, to the oil-supply tank A' to be mixed with fresh quantities of pulps, the process being thus rendered cyclic. The properties of the oil are permanently altered by treatment with chlorid of sulfur; but it may be found advisable to add a further quantity of chlorid of sulfur after the oil has been in use for some time.

The waste pulps removed from the bottom of the settling-tank C are collected in a vessel L. After agitating the pulps with the oil oil-globules, which from various causes are not completely separated by flotation, but remain in the waste pulps, can be largely separated therefrom and recovered by blowing a current of air or air and steam through jets L' upward through the waste pulps. The oil-globules rise to the surface and break, forming a film which is not liable to sink again and can be recovered by skimming or by surface baffles or the like.

It is to be understood that the form of the apparatus used can be varied without departing from this invention. For example, when separating the suspended gangue from the oil any convenient means may be used for passing the oil through warm water, and in removing the oil from the waste pulps currents of air or steam may be produced in any way. Also any other suitable method separating the values from the oil may be adopted.

What I claim as my invention, and desire to secure by Letters Patent, is—

1. The herein-described process of separating metals from their ores which consists in agitating pulps with oil until the oil has taken up all the metallic-mineral contents with some gangue, separating the mineral-bearing oil from the pulps, removing suspended particles of gangue from the oil by passing it through warm water and separating metallic minerals from the oil.

2. The herein-described process of separating metals from their ores which consists in agitating pulps with oil until the oil has taken up all the metallic-mineral contents with some gangue, separating the mineral-bearing oil from the pulps, removing suspended particles of gangue from the oil by passing it through warm water, separating metallic minerals from the oil which can be used again and recovering oil from the waste pulps by blowing air through them.

3. The herein-described process of separating metals from their ores which consists in agitating pulps with sulfo-chlorinated oil until the oil has taken up all the metallic-mineral contents with some gangue, separating the mineral-bearing oil from the pulps by flotation and removing suspended particles of gangue from the oil by passing the finely-divided oil upward through warm water.

4. The herein-described process of separating metals from their ores which consists in agitating pulps with sulfo-chlorinated oil until the oil has taken up all the metallic-mineral contents with some gangue, separating the mineral-bearing oil from the pulps by flotation, removing suspended particles of gangue from the oil by passing the finely-divided oil upward through warm water and filter-pressing the oil to separate out the metallic minerals from the oil.

5. The herein-described process of separating metals from their ores which consists in agitating pulps with mineral oil mixed with viscous oil and treated with chlorid of sulfur until the oil has taken up all the metallic-mineral contents with some gangue, separating the mineral-bearing oil from the pulps by flotation, removing suspended particles of gangue from the oil by passing the finely-divided oil upward through warm water and filter-pressing the oil to separate out the metallic minerals from the oil.

6. The herein-described process of separating metals from their ores which consists in agitating pulps with mineral oil mixed with viscous oil and treated with chlorid of sulfur until the oil has taken up all the metallic-mineral contents with some gangue, separating the mineral-bearing oil from the pulps by flotation, removing suspended particles of gangue from the oil by passing the finely-divided oil upward through warm water, filter-pressing the oil to separate out the metallic minerals from the oil and removing oil-globules from the waste pulps by spraying jets of air and steam upward through the pulps and skimming off the oil which floats.

In testimony whereof I have signed my name to this specification in the presence of two subscribing witnesses.

JACOB DAVID WOLF.

Witnesses:
CLAUDE MCKENZIE,
H. D. JAMESON.

T. J. HOOVER.

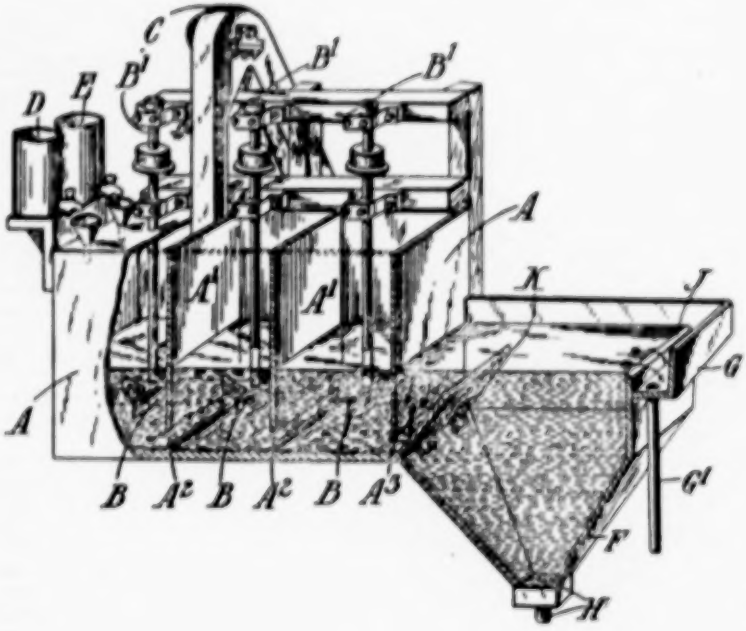
APPARATUS FOR ORE CONCENTRATION.

APPLICATION FILED MAR. 17, 1909.

1,258

953,746.

Patented Apr. 5, 1910



Witnesses
M. Wyntoop
Wm. P. Stanley.

Inventor
Theodore Jesse Hoover.
By Russell & Co

UNITED STATES PATENT OFFICE.

THEODORE JESSE HOOVER, OF LONDON, ENGLAND, ASSIGNOR TO MINERALS SEPARATION LIMITED, OF LONDON, ENGLAND.

APPARATUS FOR ORE CONCENTRATION.

953,746. Specification of Letters Patent. Patented Apr. 5, 1910.

Application filed March 17, 1909. Serial No. 483,971.

To all whom it may concern:

Be it known that I, THEODORE JESSE HOOVER, a citizen of the United States of America, residing at London, England, have invented certain new and useful Improvements in Apparatus for Ore Concentration, of which the following is a specification.

This invention relates to improvements in apparatus for ore-concentration.

Several processes are known in which air is beaten into a liquid containing powdered ore in suspension, whereupon the bubbles of air attach themselves to certain particles which are thereby caused to float, while other particles are not so floated.

The object of this invention is to improve the apparatus used in this type of process.

The invention is applicable to the process described in the United States patent of Sulman, Picard and Ballot, No. 835120, Nov. 6, 1906, in which the liquid wherein the ore is suspended contains a small proportion of oleic acid or other oil. The invention is also applicable to processes in which no oil is used.

When air is beaten into the liquid in which the ore is suspended after which the liquid is introduced into a settling vessel, the object is that the air bubbles rising to the surface of the liquid in the settling vessel should form a froth carrying the particles of metallic sulfids. In certain forms of apparatus hitherto used, a proportion of the air escaped out of the liquid or collected into large bubbles before the liquid was brought into the settling vessel, and some of the effective floating power of the air was therefore lost.

According to this invention, an apparatus for concentrating ores by gaseous flotation of certain mineral particles comprises the combination with an agitating vessel in which the liquid containing powdered ore in suspension is agitated so as to beat air into it, of a spitzkasten or like settling vessel placed immediately at the outlet of the agitation apparatus, whereby the air beaten into the liquid is most effectively used for the purpose of flotation.

Another feature of this invention consists in the employment in such an apparatus of a guide, such as a baffle or deflecting plate, arranged at the inlet of the settling vessel in such a way as to direct the stream of mineral particles and air-bubbles toward the surface of the liquid, whereby a particularly effective flotation froth is obtained.

The accompanying drawing is a diagram in perspective, illustrating one form of apparatus embodying this invention.

Several agitation vessels A are placed in series. These may conveniently be large vats separated by partitions A^1 having openings A^2 at the bottom so that the liquid may pass from one to another. Each vessel is provided with a rotatable stirrer B which is conveniently of the form shown in the drawing. Each stirrer is carried on a spindle B^1 rotated at a high speed by any convenient means.

Crushed ore or similar finely divided mineral is fed into the first vessel A through any convenient ore-feeding device such as C, and water is also fed into the vessel A. A small proportion of acid, such as sulfuric acid, may be introduced into the water from the feeding vessel D, and a small proportion of one or more other substances which enable metallic sulfids to be floated by air under the conditions hereafter specified, may be introduced from the feeding vessel E. The circuit-water may be cold or may be heated to any suitable temperature. The liquid containing ore in suspension is vigorously agitated in the agitation-vessels and escapes at the outlet A^3 highly charged with air.

A settling apparatus consisting of one or more spitzkasten F, is placed immediately at the outlet from the agitation apparatus. As shown in the drawing, the spitzkasten F has a launder G to receive the floating froth which passes away through the outlet G^1. The liquid and the sunken material pass out through the outlet H at the bottom of the spitzkasten. The level of the liquid in the spitzkasten is slightly above the lip J. Within the spitzkasten is placed an inclined baffle or guide-plate K, which may be made adjustable, extending upward from below the inlet A^3 and arranged to direct the stream of ore-particles and air-bubbles toward the surface of the liquid in the spitzkasten. The result of the use of this arrangement is that the liquid passes out of the agitation apparatus directly into the spitzkasten, whereupon the little bubbles of air rise to the surface carrying with them the mineral particles to which they are attached. The fact that the spitzkasten is

placed immediately at the outlet of the agitation apparatus insures that practically all the air introduced into the liquid shall be utilized for flotation purposes and the position of the baffle K assists the air-bubbles in carrying the metallic sulfid particles to the surface while the gangue, which is not attached to the air-bubbles, falls when it passes over the top of the baffle. The liquid which passes out of the bottom of the spitzkasten may, in addition to gangue, contain some metallic sulfids and it may therefore be again submitted to agitation and settling in a similar apparatus.

What I claim as my invention and desire to secure by Letters Patent is:—

1. In an apparatus for concentrating ores by gaseous flotation of certain mineral particles in liquid, the combination of. an agitation vessel, a spitzkasten contiguous thereto, said vessel and spitzkasten adapted to contain circuit liquid, means for agitating the contents of the agitation vessel so as to beat air into the liquid, and a wall between the agitation vessel and the spitzkasten having a wide communication orifice below the level of the liquid in both vessels, said agitation vessel adapted to discharge substantially directly into the spitzkasten.

2. In an apparatus for concentrating ores by gaseous flotation of certain mineral particles in liquid, the combination of, an agitation vessel, a spitzkasten contiguous thereto, said vessel and spitzkasten adapted to contain circuit liquid, means for agitating the contents of the agitation vessel so as to beat air into the liquid, a wall between the agitation vessel and the spitzkasten having a wide communication orifice below the level of the liquid in both vessels, and an inclined guide plate in the spitzkasten extending from below the orifice upward toward the surface of the liquid to direct the stream of mineral particles and air bubbles toward the surface of the liquid.

3. In an apparatus for concentrating ores by gaseous flotation of certain mineral particles in liquid, the combination of, an agitation vessel, a spitzkasten contiguous thereto, said vessel and spitzkasten adapted to contain circuit liquid, means for feeding ore into the agitation vessel, means for feeding circuit liquid into the agitation vessel, a rotary agitator in the agitation vessel arranged to beat air into the liquid, and a wall between the agitation vessel and the spitzkasten having a wide communication orifice below the level of the liquid in both vessels, said agitation vessel adapted to discharge substantially directly into the spitzkasten.

4. In an apparatus for concentrating ores by gaseous flotation of certain mineral particles in liquid, the combination of, an agitation vessel, a spitzkasten contiguous thereto, said vessel and spitzkasten adapted to contain circuit liquid, means for feeding ore into the agitation vessel, means for feeding circuit liquid into the agitation vessel, a rotary agitator in the agitation vessel arranged to beat air into the liquid, a wall between the agitation vessel and the spitzkasten having a wide communication orifice below the level of the liquid in both vessels, and an inclined guide plate in the spitzkasten extending from below the orifice upward toward the surface of the liquid to direct the stream of mineral particles and air bubbles toward the surface of the liquid.

5. In an apparatus for concentrating ores by gaseous flotation of certain mineral particles in liquid, the combination of, an agitation vessel, a spitzkasten contiguous thereto, said vessel and spitzkasten adapted to contain circuit liquid, means for feeding ore into the agitation vessel, means for feeding circuit liquid into the agitation vessel, a rotary agitator in the agitation vessel arranged to beat air into the liquid, a wall between the agitation vessel and the spitzkasten having a wide communication orifice below the level of the liquid in both vessels, and an inclined adjustable guide plate in the spitzkasten extending from below the orifice upward toward the surface of the liquid to direct the stream of mineral particles and air bubbles toward the surface of the liquid.

In testimony whereof I have signed my name to this specification in the presence of two subscribing witnesses.

THEODORE JESSE HOOVER.

Witnesses:
H. D. JAMESON,
F. L. RAND.

T. J. HOOVER.

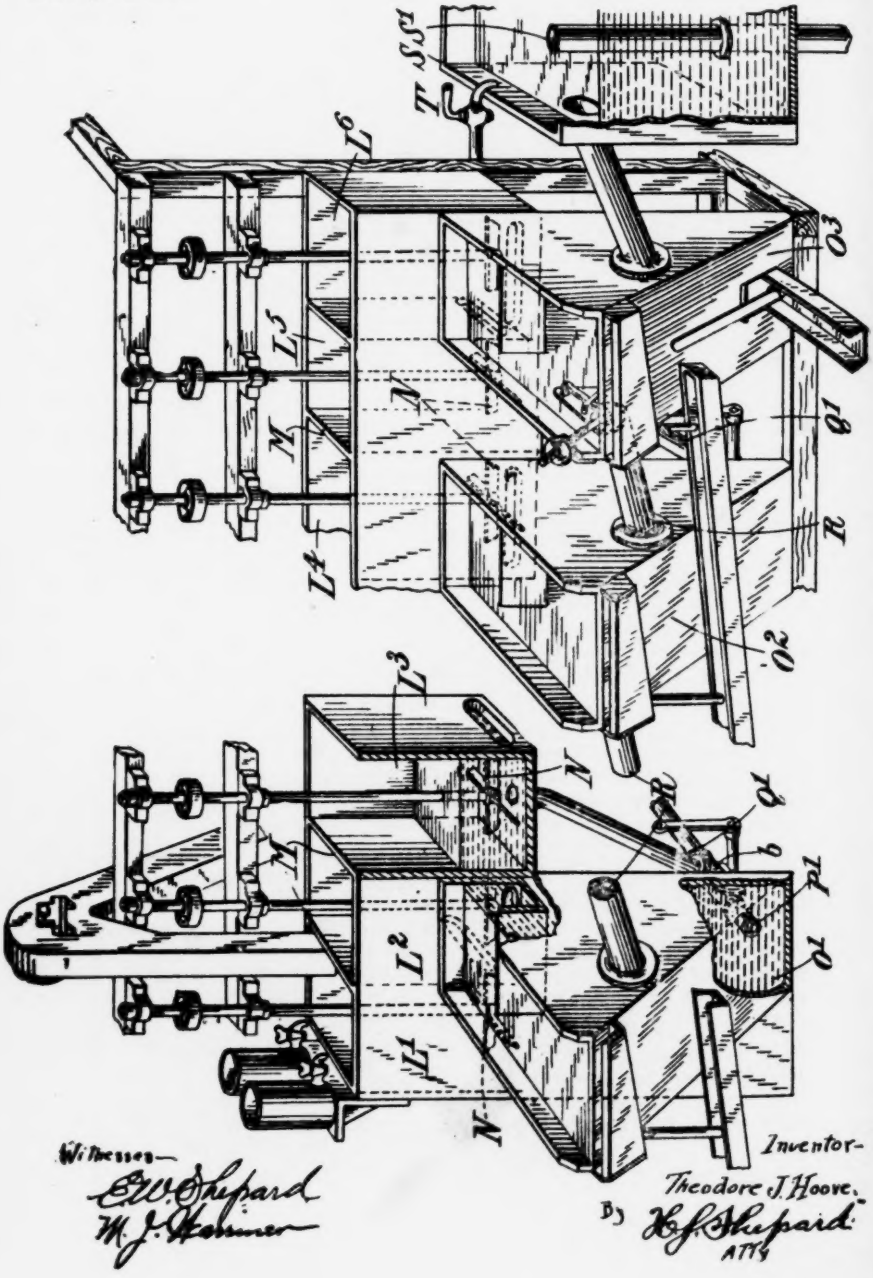
1262

APPARATUS FOR ORE CONCENTRATION.

APPLICATION FILED JULY 14, 1910.

979,857.

Patented Dec. 27, 1910.



1263 United States Patent Office.

Theodore Jesse Hoover, of London, England, Assignor to the Minerals Separation, Limited, of London, England.

Apparatus for Ore Concentration.

Specification of Letters Patent.

979,857.

Patented Dec. 27, 1910.

Application Filed July 14, 1910. Serial No. 571,989.

To all whom it may concern:

Be it known that I, Theodore Jesse Hoover, a citizen of the United States of America, residing at London, England, have invented certain new and useful Improvements in Apparatus for Ore Concentration, of which the following is a specification.

This invention relates to improvements in apparatus for ore-concentration.

Several processes are known in which air is beaten into a liquid containing powdered ore in suspension, whereupon the bubbles of air attach themselves to certain particles which are thereby caused to float, while other particles are not so floated.

The object of this invention is to improve the apparatus used in this type of process.

The invention will be best understood with reference to the accompanying drawing which is a diagrammatic illustration of one form of apparatus.

Referring to the drawing several mixing vessels (say six) L^1 L^2 L^3 L^4 L^5 L^6 are placed side by side. These may conveniently be large vats separated by partitions M. Where several vessels are connected together into a group the partitions have openings at the bottom so that the liquid may pass from one vessel to another. At the end of each group however the partitions are complete. Each vessel is provided with a rotatable agitator or stirrer N which is conveniently in the form of several radial blades (curved or straight) radiating from the bottom of a rotatable vertical shaft. Each agitator is carried by a vertical spindle rotated at a high speed by any convenient means.

Crushed ore or similar finely divided mineral is fed into the first vessel through any convenient ore feeding device and water is also fed into the vessel.

A small proportion of acid, such as sulfuric aid may be introduced into the water, and a small proportion of one or more other substances which enable metallic sulfids to be floated by air under the conditions specified may be introduced. The liquid containing ore

in suspension is vigorously agitated in the vessels. On the lateral wall of the mixing vessel, or of the last mixing vessel of the first group L^2 there is an outlet *a* at the bottom leading directly into a settling apparatus consisting conveniently of a spitzkasten O^1.

The spitzkasten is preferably constructed as shown in the drawing but instead of being connected to the end of the mixing vessel it is connected at the side. The liquid and the sunken material pass out through an outlet P^1 at the bottom of the spitzkasten and a conduit Q^1 connects said outlet with an orifice at the center of the bottom of the next succeeding mixing vessel L^3. The rotating agitator therein performs the function of a centrifugal pump and draws the liquid from the spitzkasten O^1 into said mixing vessel L^3. A suitable valved air inlet *b* controlled by a lever is provided as a part of the conduit Q^1 for the purpose of supplying the necessary air to the liquid after leaving the spitzkasten. The pulp may thus pass through a primary mixing apparatus L^1 L^2 thence through a spitzkasten O^1 into a secondary mixing apparatus L^3 L^4 thence into a second spitzkasten O^2 and through a third mixing apparatus L^5 L^6 and a third spitzkasten O^3. The spitzkasten should be all on one level. At a convenient point, say a few inches below the level of water in the spitzkasten, the spitzkasten are connected together by conduits such as short pipes R. By this means the level of water in the spitzkasten is maintained the same so that exactly the required amount of overflow is constantly maintained in each. The bulk of the circuit liquor passes away with the tailings from the bottom of the last spitzkasten.

In order to determine automatically the level of liquid in the spitzkasten, one of the spitzkasten, conveniently the last, O^3, is connected by a conduit as before with a vessel S of large area (the regulating vessel) placed alongside and filled with liquid, conveniently circuit liquor or water.

One convenient way of keeping a constant level in the regulating vessel is to provide an overflow pipe S^1 the open top of which is at the desired level or a pipe can be so placed that it introduces water into the regulating vessel whenever the level falls below the normal. The regulating vessel may simply be provided with a very small supply of water constantly running in through a tap T at a rate arranged to give the necessary overflow in the spitzkasten or the regulating vessel S may have both an overflow pipe S^1 and an inlet of water through tap T.

Modifications may be made in the details of the invention provided always that the spirit of the invention is not departed from.

1264 What I claim as my invention and desire to secure by Letters Patent is:

1. Apparatus for concentrating ores by gaseous flotation of certain mineral particles in liquid comprising in combination a mixing vessel, an agitator in the mixing vessel, a spitzkasten at the outlet of the mixing vessel, a secondary mixing vessel, a centrifugally acting agitator in said secondary mixing vessel and a connecting conduit between the tailings outlet of the spitzkasten and the zone of the suc-

tion influence of the centrifugally acting agitator of said secondary mixing vessel.

2. Apparatus for concentrating ores by gaseous flotation of certain mineral particles in liquid comprising a mixing vessel, an agitator in said mixing vessel, a spitzkasten at the outlet of said mixing vessel, a secondary mixing vessel, a connecting conduit between the tailings outlet of the spitzkasten and the center of the bottom of said secondary vessel and a centrifugally acting agitator in said secondary mixing vessel.

3. An apparatus for concentrating ores by gaseous flotation of certain mineral particles in liquid comprising in combination a plurality of mixing vessels connected as a group, an agitator in each of said mixing vessels, a spitzkasten at the outlet of said group of mixing vessels a plurality of secondary mixing vessels connected as a group, a centrifugally acting agitator in said secondary mixing vessel, and a connecting conduit between the spitzkasten and the zone of the suction influence of the centrifugally acting agitator.

4. An apparatus for concentrating ores by gaseous flotation of certain mineral particles in liquid comprising in combination a first mixing vessel, an agitator in the mixing vessel, a spitzkasten at the outlet of the mixing vessel, a secondary mixing vessel at substantially the same level as the first mixing vessel, a centrifugally acting agitator in said secondary mixing vessel, and a connecting conduit between the tailings outlet of the spitzkasten and the zone of the suction influence of the centrifugally acting agitator in the secondary mixing vessel.

5. An apparatus for concentrating ores by gaseous flotation of certain mineral particles in liquid comprising in combination a mixing vessel, a spitzkasten at the outlet of said mixing vessel, a secondary mixing vessel a centrifugally acting agitator therein, and a connecting conduit between the tailings outlet of the spitzkasten and the zone of the suction influence of the centrifugally acting agitator in the secondary mixing vessel, said conduit being provided with an air inlet.

6. An apparatus for concentrating ores by gaseous flotation of certain mineral particles in liquid comprising in combination a series of mixing vessels, a centrifugally acting agitator in each, a series of spitzkasten placed respectively at the outlets from the mixing vessels and at the same level with one another, a conduit from the tailings outlet of each spitzkasten to the zone of the suction influence of the centrifugally acting agitator of the next succeeding mixing vessel, and a valve controlled air inlet in said connecting conduit.

7. Apparatus for concentrating ores by gaseous flotation of certain mineral particles in liquid, comprising in combination a series of mixing vessels, a centrifugally acting agitator in each, a series of spitzkasten placed respectively at the outlets from the mixing vessels and on the same level with one another, a conduit from the tailings outlet of each spitzkasten to the zone of the suction influence of the centrifugally acting agitator of the next succeeding mixing vessel and a connecting conduit near the top but under the liquid level between each pair of adjacent spitzkasten.

8. Apparatus for concentrating ores by gaseous flotation of certain mineral particles in liquid, comprising in combination a series of mixing vessels, a centrifugally acting agitator in each, a series of spitzkasten placed respectively at the outlets from the mixing vessels and on the same level with one another, a conduit from the tailings outlet of each spitzkasten to the zone of the suction influence of the centrifugally acting agitator of the next succeeding mixing vessel and a connecting conduit near the top but under the liquid level between each pair of adjacent spitzkasten, a vessel of relatively large area connected by a conduit with one of the spitzkasten and means for maintaining constant the level of the solution therein.

In testimony whereof I have signed my name to this specification in the presence of two subscribing witnesses.

THEODORE JESSE HOOVER.

Witnesses:
H. D. JAMISON.
N. WILLIAMS.

1265 Third Edition.

A. D. 1860, 23rd February. No. 488.

Obtaining Metals from Ores.

Letters Patent to William Haynes, of Bank Place, Holywell, in the County of Flint, Metallurgist, for the Invention of "Improvements in Obtaining Metals from their Ores or Matrices."

Sealed the 17th August, 1860, and Dated the 23rd February, 1860.

Provisional Specification left by the said William Haynes at the Office of the Commissioners of Patents, with his Petition, on the 23rd February, 1860.

I, William Haynes, of Bank Place, Holywell, in the County of Flint, Metallurgist, do hereby declare the nature of the said Invention for "Improvements in Obtaining Metals from their Ores or Matrices," to be as follows:—

The nature of the Invention is this:—I first grind the ore to powder and sift it, so as to secure its being of the requisite fineness, and then add what I term my "agent." This is composed of certain substances not soluble in water alone, such as bituminous matter, coal tar from gasworks, and such like; for instance gums or gummy matter, such, for instance, as india-rubber and gutta percha, and fatty or oleaginous matters, and having mixed these together I add one part of this mixture to from five to nine parts of the powdered ore, and then I incorporate the whole together by mixing it in a mixing machine; which being done, I add a sufficient quantity of water to cover the whole bulk, and then pass the same into a triturating machine. Here the separation of the metals from the other portion of the ores or matrices commences, and when the
1266 earthy or foreign matter has separated from the "agent" & metal, I remove such earthy or foreign matter, and replace it by fresh ore or matrix, and repeat this till I find my "agent" will take up no more metal.

To remove the "agent" from the metal, I put the "agent" and metal in an alkaline solution, and in due time the metal is precipi-

tated and can be removed for use, and the agent used again, the alkaline being crystallised, and thus removed from it. The earthy or foreign matter thus freed from metallic admixture will often be valuable for commercial purposes. The details of this Invention admit of variation according to the varied circumstances of operation.

Specification in pursuance of the conditions of the Letters Patent, filed by the said William Haynes in the Great Seal Patent Office on the 23rd August, 1860.

To all to whom these presents shall come, I, William Haynes, of Bank Place, Holywell, in the County of Flint, Metallurgist, send greeting.

Whereas Her most Excellent Majesty Queen Victoria, by Her Letters Patent, bearing date the 23rd day of February, in the year of our Lord One thousand eight hundred and sixty, in the twenty-third year of Her reign, did, for Herself, Her heirs and successors, give and grant unto me, the said William Haynes, Her special license that I, the said William Haynes, my executors, administrators, and assigns, or such others as I, the said William Haynes, my executors, administrators, and assigns, should at any time agree with, and no others, from time to time and at all times thereafter during the term therein expressed, should and lawfully might make, use, exercise, and vend within the United Kingdom of Great Britain and Ireland, the Channel Islands, and Isle of Man, an Invention for "Improvements in Obtaining Metals from their Ores or Matrices," upon the condition (amongst others) that I, the said William Haynes, my executors or administrators, by an instrument in writing under my, or their or one of their hands and seals, should particularly describe and ascertain the nature of the said Invention, and in what manner the same was to be performed, and cause the same to be filed in the Great Seal Patent Office within six calendar months next and immediately after the date of the said Letters Patent.

Now know ye, that I, the said William Haynes, do hereby declare the nature of my said Invention, and in what manner the
1267 same is to be performed, to be particularly described and ascertained in and by the following statement, that is to say:—

(I.) The nature of the said Invention, as hath been heretofore described in the Provisional Specification filed on application for the said Letters Patent, consists in this, viz., that having first ground the ore or matrix (or ore and matrix) to powder, and sifted it so as to secure its being of the requisite fineness, I add thereto what I term my "agent," which is composed of certain substances not soluble in water alone, that is, bituminous matter (coal tar from gasworks, and such like, for instance), gums or gummy matter (amongst others, gutta percha, india-rubber, for instance), and fatty or oleaginous matter, and having mixed these together I add one part of the mixture thus made to from five to nine parts of the ore, or ore and matrix, and then I incorporate the whole together by agitation of the same in a mixing machine; which being done, I add a sufficient quantity

of water to cover the whole bulk, and if thought desirable, pass the same into a triturating machine, when, upon working the said triturating machine, the separation of the metals from the other portions of the ores or matrices commences, although the separation could be effected in the mixing machine, as is hereafter described; and when the earthy or foreign matter has separated from the agent and metal, which alone remain in union, I remove such earthy or foreign matter, and replace it by fresh ore or matrix, and repeat this till I find my "agent" will take up no more metal. To remove the "agent" from the metal, I put the agent in an alkaline solution, and in due time the metal is precipitated, and can be removed for use, the alkali, if desired, being crystallized, and thus removed from it. The earthy or foreign matter thus freed from the metal, but combined with the alkaline solution, will often be valuable for commercial purposes.

(II.) In order the better to exemplify in what manner the same Invention is to be performed or put in practice, I would further state, that having as aforesaid crushed the ore or matrix, or ore and matrix, by any suitable method adopted for crushing ores and matrices, and passed the same through a sieve or sifting apparatus of 100 meshes to the lineal inch, or thereabouts, I add to the finely divided substance thus obtained, one part, by weight, of my "agent," to from 5 to 9 parts of this sifted ore, if intended to be treated according to my Invention; the variation in the amount of the "agent" in proportion to the quantity of ore being governed by its character, as for carbonaceous ores, 5 parts, or thereabouts, might be sufficient; whilst for sulphates and sulphurets, 7 to 9 parts would be required, according to the predominance of sulphur.

1268 What I term my "agent" is prepared by mixing together some of the substances mentioned in the outset of this Specification; the particular substances chosen being so chosen in accordance with the known chemical affinity or properties of the particular ore to be operated upon. Thus, to take the instance of rich sulphates or sulphurets, I make a mixture of 1 part of common resin and 4 or 8 parts of coal tar, the use of the greater number than 4 parts of coal tar being necessary when the same is not highly bituminous.

Or, my agent is prepared thus:—1 part, by weight, of oily or fatty matter to from 4 to 8 parts of bituminous, resinous, or waxy matter; the difference between 4 and 8 parts being regulated by the character of the ore; ores containing much lime, or forms of lime, requiring the less number of these parts. This last-mentioned form of "agent" is adapted for all ores, except sulphates and sulphurets, or other sulphur-bearing ores.

In preparing my agent I prefer to use such bituminous and resinous substances and oleaginous, fatty, or waxy matter as may be soluble in alkali. Or, instead of the above, I form my agent of one part of coal tar to 2 parts of india-rubber or gutta percha; but when this agent is applied to the ore, I require to add water heated to 100 degrees of Fahrenheit's thermometer at least, instead of cold water, which answers for the other forms of my agent, though I prefer warm water in all cases.

Having thus prepared the agent in accordance with the character of the ore about to be treated, I apply it to the finely-divided ore as aforesaid by mixing the ore and agent together in a "mixing machine, that is, in an ordinary brickmaker's pug mill, or mortar mixer, or in any other apparatus that will effect the due mechanical admixture of the "agent" and the ore; which being done, I add as circumstances may require, either hot, warm, or cold water sufficient to well cover the whole, as herein-before referred to. Whereupon the agitation being still kept up, the agent acts upon the metal, and gradually effects the separation of the metal from the earthy or non-metallic matters of the ore or matrix, or ore and matrix, the earthy matter sinking to the bottom of the water, and the metal being retained by the agent. I might here observe that where I speak of ore only, ore or matrix, or ore and matrix, should be understood.

To remove the agent from the metal, I put the agent and metal still in union in a vessel containing an alkaline solution, for instance, a strong solution of caustic soda in water, and in a short time the metal is precipitated to the bottom, and may be removed.

With regard to the agent having the india-rubber or gutta percha, or both, in its composition, I may be that it will be found
1269-70 particularly useful for gold-bearing, quartz, or siliceous ores.

The alkali and agent combined being a saponaceous matter, may be sold to soap makers and others as a commercial product; or this saponaceous solution may be used for the next operation, and so on, and then used for soap. Where the refuse is silica, it will be found available for commercial uses, being in fine powder.

(III.) Having now described the nature of the said Invention, and in what manner the same is to be performed, I declare that I claim the Invention of improvements in obtaining metals from their ores and matrices effected by the use of the substances described in the outset (marked I.) of this my Specification, in the manner herein-before set forth.

In witness whereof, I, the said William Haynes, have hereunto set my hand and seal, this 23rd day of August, in the year of our Lord One thousand eight hundred and sixty.

WILLIAM HAYNES. [L. S.]

Signed and sealed in my presence,
F. W. CAMPIN,
Patent Agent, 156 *Strand*.

Redhill: Printed for His Majesty's Stationery Office, by Love & Malcomson, Ltd., (Wt. 25-50 10, 1907.)

1271 [Second Edition.]

No. 840. A. D. 1889.

Date of Application, 16th Jan., 1889.

Complete Specification Left, 12th Oct., 1889—Accepted, 23rd Nov., 1889.

Provisional Specification.

Improvements in Apparatus for Mixing, Incorporating, or Effecting the Circulation of Liquids and Semi Liquids in Vessels.

We, Samuel Bagster Boulton, Thomas Burt Haywood, and Harold Edwin Boulton, trading under the firm of Burt, Boulton, and Haywood, of 64 Cannon Street, in the City of London, Manufacturers, and Edmund Rich Gabbett, of Old Charlton, Kent, Civil Engineer, do hereby declare the nature of this invention to be as follows:—

According to this invention we effect the mixing or incorporation of liquids or semi liquids or the circulation of a liquid within a cauldron or tank by the action of centrifugal force upon part of such liquid or liquids in such manner that a body of liquid is thereby continuously withdrawn from the bottom and delivered at the top, or vice versa, thus producing a continuously ascending or descending column of fluid within the apparatus and a corresponding movement in the contrary direction in the body of liquid outside the apparatus. By thus effecting the mixing of circulation of the liquid entirely by centrifugal action we avoid in a great measure the loss of power due to the friction of mechanical devices moving in the liquid, such as occur in apparatus with helical propelling blades and the like heretofore employed.

The apparatus may be constructed in various ways for operating according to our invention; thus according to one arrangement we employ a conical, conoidal, paraboloidal or hemispherical shell immersed in a vertical position in the liquid and having both its upper and lower ends open, the end of larger diameter being situated at top if the circulation is to be in an upward direction through it, and at bottom if a downward circulation is required.

This shell is fixed by suitable arms to a central shaft carried in

bearings above the cauldron or vat, so that when more or less rapid rotary motion is imparted to it, and consequently to the body of liquid situated within it, the centrifugal force will act in the well known manner upon such body of liquid, causing it to rise up on the inner walls of the shell and to flow over the upper edge thereof, into the body of liquid surrounding it, while at the same time fresh liquid will enter the lower end of the shell to replace that which is ejected at top. In place of only a single shell two or more concentric shells may be employed so as to cause a body of liquid to ascend the sides of each shell by centrifugal action, or the body of ascending liquid can be confined within an annular space formed between two concentrical shells, the inner one of which has no opening at the lower end.

When the upper end of the shell is immersed more or less below the level of the liquid, the central part of the upper opening thereof may be covered in by a shield so as to prevent the pressure of the column of liquid above the shell from interfering with the centrifugal action. In order to prevent slip between the inner surface of the shell and the liquid in contact therewith, the shell may be provided with internal longitudinal ribs or vanes.

According to another modification the shell is constructed with the lower end of more or less cylindrical tubular form, while the upper end is widened out to a trumpet-mouth shape, and the central part of this may also be more or less enclosed so that the centrifugal action in ejecting the liquid from the annular orifice thus formed will cause the liquid to be drawn up by the suction produced. Or the entire shell may be of a trumpet mouth shape, and it may be provided with an inner shell as above described with reference to the conical form.

Or, again, the upper end may be formed into two or more hollow horizontal arms communicating at the centre with the vertical
1272 tubular part, so that the liquid in being ejected by centrifugal action from the hollow arms will produce a suction in the vertical tube.

According to another modification, instead of employing a continuous shell a number of separate tubular or trough shaped channels may be employed, receding from the central axis as they proceed upward, so that the liquid entering their lower ends is caused to ascend in them by centrifugal action, and flows out at the upper ends.

In all the above described constructions the reverse action may be obtained, that is to say, the liquid may be made to flow downward through the apparatus by inverting the position of the latter.

In cases where it is preferred to suspend the shaft of the apparatus from bearings above the cauldron or tank, the downward pressure on the bearings due to the weight of the shell may be reduced by making the latter more or less buoyant either by forming it hollow with closed air spaces, or by combining therewith a float of any suitable construction.

The above described invention is applicable with particular advantage in cases where the material to be acted upon requires to be

maintained at a comparatively high temperature in order to maintain it in a liquid condition, as in such cases the employment of an ordinary circulating pump within the vessel or cauldron would be subject to considerable difficulties.

Dated this 16th day of January, 1889.

ABEL & IMRAY,
Agents for the Applicants.

Complete Specification.

Improvements in Apparatus for Mixing, Incorporating, or Effecting the Circulation of Liquids and Semi Liquids in Vessels.

We, Samuel Bagster Boulton, Thomas Burt Haywood, and Harold Edwin Boulton trading under the firm of Burt Boulton and Hayward of 65 Cannon Street in the City of London Manufacturers and Edmond Rich Gabbett of Old Charlton Kent, Civil Engineer, do hereby declare the nature of this invention and in what manner the same is to be performed to be particularly described and ascertained in and by the following statement:—

According to this invention we effect the mixing or incorporation of liquids or semi-liquids or the circulation of a liquid within a cauldron or tank, by the action of centrifugal force upon part of such liquid or liquids in such manner that a body of liquid is thereby continuously withdrawn from the bottom and delivered at the top or vice versa, thus producing a continuously ascending or descending column of fluid within the apparatus and a corresponding movement in the contrary direction in the body of liquid outside the apparatus. By thus affecting the mixing or circulation of the liquid entirely by centrifugal action we avoid in a great measure the loss of power due to the friction of mechanical devices moving in the liquid, such as occur in apparatus with helical propelling blades and the like, heretofore employed.

The apparatus may be constructed in various ways for operating according to our invention, thus according to one arrangement we employ a shell of a conical, conoidal, paraboloidal, hemispherical or trumpet mouthed shape fitted if necessary with internal ribs and immersed in a vertical position in the liquid, and having both its upper and lower ends open, the end of larger diameter being situated at top if the circulation is to be in an upward direction through it, and at bottom if a downward circulation is required. The shell is fixed by suitable arms to a central strap carried in bearings above the cauldron or vat, so that when more or less rapid rotary motion is imparted to it and consequently to the body of liquid situated within it, the centrifugal force will act in the well known manner upon such body of liquid causing it to rise up on the inner wall of the shell and to flow over the upper edge then into the body of
1273 liquid surrounding it, while at the same time fresh liquid will enter the lower end of the shell to replace that which is ejected at top.

Holes or openings may be made in the shell or tubes at various heights to assist the distribution of the inner column of liquid or semi liquid, through the outer body or the shell may have reciprocating motion vertical or horizontal given to it or it may be made to travel round a centre for the same purpose.

Fig. 1 of the accompanying drawings shews a vertical section of one form of the above described apparatus, and Fig. 2 shews a plan.

A is a conical shell having interval ribs A^1 and mounted on a shaft B by which it is suspended within the vessel or tank C containing the liquid to be acted upon, the shaft being carried at its upper end by a bracket D and guided by a bush or stuffing box E on the cover of the vessel C.

Assuming this vessel to be charged with liquid to the level indicated and the shell A to be rotated by suitable gearing such as indicated at F then the body of liquid within the shell being carried round with the same by means of the ribs A^1, the centrifugal force will cause the liquid to rise along the inclined inner surface of the shell and to be ejected into the surrounding liquid when arriving at the upper edge thereof while at the same time the pressure of the surrounding column of liquid in the vessel C, will cause fresh quantities of liquid to enter the lower end of the shell A to make good the quantity discharged at the top. Thus a continuous circulation and consequent mixing of the liquid will be effected as indicated by the arrows.

To prevent the carrying round of the body of liquid in the vessel C by its frictional contact with the outer surface of the shell A, the vessel may be provided with projecting ribs C^1 as shewn, this is however not absolutely necessary and such rotation of the liquid may to some extent be prevented by making the vessel C rectangular instead of circular as shewn, or by arranging a set of two or more revolving shells such as A in the vessel, either grouped round a central driving shaft or arranged in a row. Also instead of rotating the shell or shells A continuously in one and the same direction they may have their direction of rotation reversed after any desired intervals of time. This might be effected by applying two driving pullies carrying respectively an open and a crossed strap which are shifted alternately on to a loose pulley, as is well understood.

The circulation of the liquid can also be made to take place in the contrary direction to that described by inverting the position of the shell A so that the centrifugal action will cause the liquid within it to travel in a downward direction.

The shell A may also, if desired have an oscillating motion imparted to it, so as to move continuously or intermittently with its lower end to different parts of the vessel C, and thus cause the liquid to be drawn consecutively from such different parts.

This might be effected by connecting the lower part of the shaft B carrying the shell to the upper part running in fixed bearings by a universal joint, and imparting the described motion to and fro thereto by a crank, cam or excentric and connecting rod or by other suitable means.

The shell A may be made to extend above the level of the liquid, instead of being entirely immersed as indicated.

Figs. 3 to 10 shew diagram sections of various other forms which may be adopted for the revolving shell. Fig. 3 shews a paraboloidal shape, Fig. 4 a construction with hemispherical lower part and cylindrical upper part, the centrifugal action which drives the fluid upward being confined to the lower part. Fig. 5 shews an arrangement in which there are two or more concentric shells, on each of which a body of liquid will be made to ascend by centrifugal action or there may be only two concentric shells as at Fig. 6 forming a narrow annular space in which the liquid ascends, there being no opening in the inner shell. If the shell has its upper end immersed to a considerable extent below the liquid level, the arrangement shewn at Fig. 7 may be adopted in which the top of the shell A is covered by a shield A^1 leaving a narrow annular orifice at *a*
1274 for the issue of the liquid. By this means the pressure of the column of liquid which would otherwise exist in the centre of the shell, is prevented from interfering with the centrifugal action. Fig. 8 shews a construction in which the lower part of the shell is made cylindrical while the upper part is made trumpet mouthed, the centrifugal action being in this case confined to the upper part or the entire shell might be made of a trumpet mouth shape.

Fig. 9 shews a construction with the lower part A more or less cylindrical and terminating at top in two or more tubular arms A^1 which may be either radial or curved. Fig. 10 shews a construction in which instead of employing a continuous shell two or more separate curved or inclined tubular or trough shaped channels A A are used, open at the upper and lower ends so that in revolving the liquid will be caused by the centrifugal action to rise in the tubes or troughs and be discharged at the upper ends in the same way as with the above described shells.

Such tubes or channels may also be made with a helical curvature relatively to the axis of rotation so as to assist in producing the upward or downward motion of the liquid.

If found advantageous to lessen the weight or load on the bearings of the shaft by which the shell is revolved, this can be effected by having an air tight chamber connected to the shell or shaft; thus for instance the shield A^1 shewn in Fig. 7 being made hollow will by its flotation partly carry the weight of the shell &c. or in the — of Fig. 6 if the inner vessel is covered and rendered air tight, the same purpose will be attained.

Although it is preferred to impart the necessary rotary motion to the shell by gearing as described yet it will be evident that other means might be employed, such as a turbine fitted on the shaft of the shell and driven by steam or other fluid.

The above described invention is applicable with particular advantage in cases where the material to be acted upon requires to be maintained at a comparatively high temperature in order to maintain it in a liquid condition, as in such cases the employment of an ordinary circulating pump within the vessel or cauldron would be subject to considerable difficulties.

Having now particularly described and ascertained the nature of this invention and in what manner the same is to be performed we declare that what we claim is:—

1. In apparatus for mixing incorporating or effecting the circulation of liquids and semi liquids the use of a vessel shell or tube or combination of vessel shells or tubes partly or wholly immersed in the liquid and having its or their upper and lower ends open, such vessel shell or tube being so formed as when rotated upon its vertical axis it will cause the liquid to rise or descend in the same by centrifugal action and to be discharged at the upper or lower end substantially as herein described.

2. In apparatus for mixing incorporating or effecting the circulation of liquids, and semi liquids, the combination with the tank or cauldron C of a shell A of conical conoidal or equivalent shape with internal ribs or projections A^1 and carried by a vertical axis B driven by suitable gearing so as to cause the liquid in the tank or cauldron to ascend in the shell by centrifugal action and to be discharged into the tank at the upper end while at the same time fresh liquid is made to enter at the lower end, substantially as herein described with reference to Figs. 1 and 2 of the accompanying Drawings.

3. In apparatus for mixing incorporating or effecting the circulation of liquids and semi liquids the use of a tubular shell A with arms A^1 carried by a vertical revolving axis and partly or wholly immersed in the liquid so that by the centrifugal action of the arms, A^1 the liquid is drawn up through the tubular shell A and expelled through the arms A^1 substantially as described with reference to Fig. 9.

4. In apparatus for mixing incorporating or effecting the circulation of liquids and semi liquids the use of tubular or trough shaped arms A curved by a vertical revolving axis and partly or wholly immersed in the liquid so that by the centrifugal action of
1275 the arms the liquid is caused to rise through them and to be ejected through the upper ends thereof, substantially as herein described with reference to Fig. 10.

Dater this 11th day of October 1889.

ABEL & IMRAY,
Agents for the Applicants.

London: Printed for Her Majesty's Stationery Office, by Darling & Son, Ltd.—P 10798-50-9/94-G 2170.

(2nd Edition) SHEET 1.

Fig. 1.

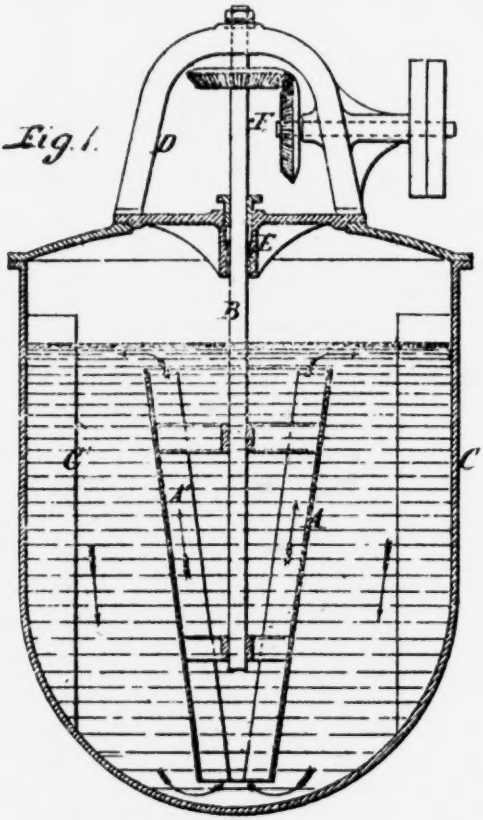
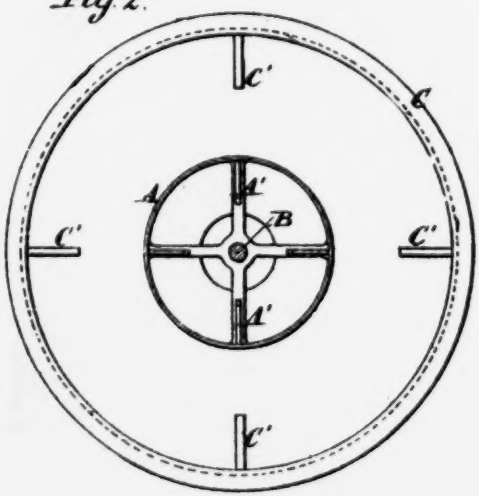


Fig. 2.



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[This Drawing is a reproduction of the Original on a reduced scale]

Fig 3

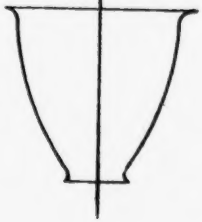


Fig 4.

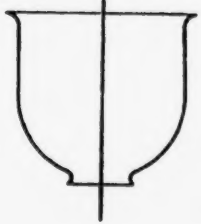


Fig 5.

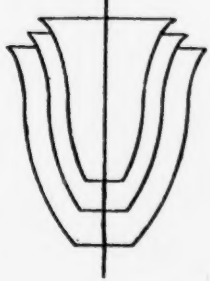


Fig. 6.

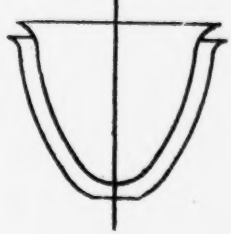


Fig. 7

Fig. 8.

Fig. 9.

Fig. 10.

1277 Second Edition.

No. 7803. A. D. 1905.

Date of Application, 12th April, 1905.

Complete Specification Left, 3rd June, 1905—Accepted, 18th Jan., 1906.

Provisional Specification.

"Improvements in or Relating to Ore Construction."

We, Henry Livingstone Sulman, Metallurgist, of 44 London Wall, Hugh Fitzalis Kirkpatrick Picard, Metallurgist, of 44 London Wall, and John Ballot, Merchant, of 62 London Wall, all of the City of London, do hereby declare the nature of this invention to be as follows—

This invention relates to improvements in the concentration of ores, the object being to separate metalliferous matter, graphite and the like from gangue, by means of oils, fatty acids or other substances which have a preferential affinity for metalliferous matter over gangue.

In the process described in the Specification of British Letters Patent No. 18589 of 1903 granted to A. E. Cattermole, an amount of oil varying from 4% to 6% of the weight of metalliferous matter present is agitated with an ore pulp so as to form granules which can be separated from the gangue. In the Specification of British Patent No. 17109 of 1903 granted to A. E. Cattermole and others, a similar method of separation is employed, oleic acid being produced in situ in the ore pulp.

We have found that if the proportion of oily substance be considerably reduced, say to a small fraction of 1% on the ore, granulation ceases to take place and on vigorous agitation, there is a tendency for a part of the oil-coated metalliferous matter to rise to the surface of the pulp in the form of a froth or scum.

This tendency is dependent on a number of factors. Thus, the water in which the oiling is effected is preferably slightly acidified

by adding say a fraction of 1% up to 1%, of sulphuric acid or other mineral acid or acid salt, the effect of this acidity being to prevent gangue from being coated with oily substance, or in other words, to render the selective action of the oil more marked; but it is to be understood that the object of using acid in the pulp according to this invention is not to bring about the generation of gas for the purpose of flotation thereby, and the proportion of acid used is insufficient to cause chemical action on the metalliferous minerals present.

Again, we have discovered that the tendency for the oily substance to disseminate through the pulp and the rapidity with which the metalliferous matter becomes coated is increased if the pulp is warmed.

The formation of froth is assisted by the fine pulverization of the ore and we find that slime mineral most readily generates scum and rises to the surface while larger particles have less tendency to be included in the froth.

The proportion of mineral which floats in the form of froth varies considerably with different ores and with different oily substances, and before utilising the facts above mentioned in the concentration of any particular ore a simple preliminary test is necessary to determine which oily substance yields the proportion of froth or scum desired.

The following is an example of the application of this invention to the concentration of a particular ore.

An ore containing ferruginous blende, galena, and gangue consisting of quartz, rhodonite, and garnet, is finely powdered and mixed with water containing a fraction of 1% or up to 1% of a mineral acid or acid salt, conveniently sulphuric acid, or mine or other waters containing ferric sulphate. To this is added a very small
1278 proportion of oleic acid (say, from 0.02% to 0.5% on the weight of ore), the mixture is warmed say to 30° to 40° C. and is agitated in a cone mixer or the like, as in the processes previously cited, for about 2½ to 10 minutes, until the oleic acid has been brought into efficient contact with all the mineral particles in the pulp.

When agitation is stopped a large proportion of the mineral present rises to the surface in the form of a froth or scum which has derived its power of flotation mainly from the inclusion of air bubbles introduced into the mass by the agitation, such bubbles or air films adhering only to the mineral particles which are coated with oleic acid. The minimum amount of oleic acid which can be used to effect the flotation of the mineral in the form of froth may be under 0.1% of the ore, but this proportion has been found suitable and economical.

If the ore was crushed to 90 mesh to the linear inch (half of which ore will pass through 150 mesh sieve) the froth may contain about 70% to 80% of the metalliferous matter present in the ore. This froth is removed from the pulp by spitzkast, upcast, skimming, draining or otherwise and is caused to subside; the coated metallifer-

ous matter is separated from the liquid and treated with an alkali which removes the oleic acid in the form of a soap.

If desired, the oleic acid used in the first instance may be produced in situ in the pulp by decomposing a dilute soap solution with mineral acid as described in the British Patent No. 17109 of 1903 cited above.

The metalliferous matter which did not form part of the froth (generally the larger particles) remains in admixture with the gangue in the pulp. To recover this, the pulp is distributed in a thin layer on a shaking table, convex buddle or the like, whereon the mineral is exposed to a free air surface, which exposure may be increased by the application of an air blast or air jets or the like, and thereafter brought on to the edge or surface of liquid whereby the metalliferous matter floats and is separated from the gangue which sinks as described in the Specification of our British Patent Application No. 29374 of 1904.

The proportion of mineral recovered in the froth and that recovered by table flotation may be considerably varied but generally speaking the froth will separate the slime mineral while the larger particles are recovered by the latter method.

Dated this 12th day of April, 1905.

BOULT, WADE & KILBURN,
Agents for the Applicants.

Complete Specification.

Improvements in or Relating to Ore Concentration.

We, Henry Livingstone Sulman, Metallurgist, of 44 London Wall, Hugh Fitzalis Kirkpatrick Picard, Metallurgist, of 44 London Wall, and John Ballot, Merchant, of 62 London Wall, all of the City of London, do hereby declare the nature of this invention and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement:

This invention relates to improvements in the concentration of ores, the object being to separate metalliferous matter, graphite and the like from gangue, by means of oils, fatty acids or other substances which have a preferential affinity for metalliferous matter over gangue.

In the process described in the previous British Patent No. 18589 of 1903, granted to A. E. Cattermole, an amount of oil
1279 varying from 4% to 6% of the weight of metalliferous matter present is agitated with an ore pulp so as to form granules which can be separated from the gangue. In the previous British Patent No. 17109 of 1903, granted to A. E. Cattermole and others, a similar method of separation is employed, oleic acid being produced in situ in the ore pulp.

We have found that if the proportion of oily substance be considerably reduced, say to a fraction of 1% on the ore, granulation ceases to take place and after vigorous agitation, there is a tendency for a

part of the oil-coated metalliferous matter to rise to the surface of the pulp in the form of a froth or scum.

This tendency is dependent on a number of factors. Thus, the water in which the oiling is effected is preferably slightly acidified by adding say a fraction of 1% up to 1%, of sulphuric acid or other mineral acid or acid salt, the effect of this acidity being to prevent gangue from being coated with oily substance, or in other words, to render the selective action of the oil more marked; but it is to be understood that the object of using acid in the pulp according to this invention is not to bring about the generation of gas for the purpose of flotation thereby, and the proportion of acid used is insufficient to cause chemical action on the metalliferous minerals present.

Again, we have discovered that the tendency for the oily substance to disseminate through the pulp and the rapidity with which the metalliferous matter becomes coated is increased if the pulp is warmed.

The formation of froth is assisted by the fine pulverisation of the ore and we find that slime mineral most readily generates scum and rises to the surface while larger particles have less tendency to be included in the froth.

The proportion of mineral which floats in the form of froth varies considerably with different ores and with different oily substances, and before utilising the facts above mentioned in the concentration of any particular ore a simple preliminary test is necessary to determine which oily substance yields the proportion of froth or scum desired.

The following is an example of the application of this invention to the concentration of a particular ore.

An ore containing ferruginous blende, galena, and gangue, consisting of quartz, rhodonite, and garnet, is finely powdered and mixed with water containing a fraction of 1% or up to 1% of a mineral acid or acid salt, conveniently sulphuric acid, or mine or other waters containing ferric sulphate. To this is added a very small proportion of oleic acid or petrol, or other suitable oil (say, from 0.02% to 0.5% on the weight of ore), the mixture is warmed say to 30° to 40° C. and is briskly agitated in a cone mixer or the like, as in the processes previously cited, for about 2½ to 10 minutes, until the oleic acid petrol oil etc., has been brought into efficient contact with all the mineral particles in the pulp.

When agitation is stopped a large proportion of the mineral present rises to the surface in the form of a froth or scum which has derived its power of flotation mainly from the inclusion of air bubbles introduced into the mass by the agitation, such bubbles or air films adhering only to the mineral particles which are coated with oleic acid namely the blende and galena. The minimum amount of oleic acid or petrol etc. which can be used to effect the flotation of the mineral in the form of froth may be under 0.1% of the ore, but this proportion has been found suitable and economical.

If the ore were crushed to 90 mesh to the linear inch (half of which ore will pass through 150 mesh sieve) the froth may contain about 70% to 80% of the metalliferous matter present in the ore. This

froth is removed from the pulp by spitzkast, upcast, skimming, draining, or otherwise; after subsidence the oil-coated metalliferous matter removed as froth is separated from any liquid which may have accompanied it and treated with a dilute solution of caustic alkali which removes the oleic acid petrol oil etc. in the form of a solution of soap.

1280 If desired, the oleic acid used in the first instance may be produced in situ in the pulp by decomposing a dilute soap solution with mineral acid as described in the British Patent No. 17,109 of 1903 cited above. The oleic acid or other fatty acid forming the coating on the metalliferous matter which produces the froth, may give rise to insoluble soaps on the surface of the metalliferous matter if soluble lime, iron or other salts are present in small quantity during the production, or on the breaking down of the froth with alkali, such insoluble soaps are difficult to remove and are capable of adhering to air and causing flotation much the same as the fatty acids do.

The metalliferous matter which did not form part of the froth (generally the larger particles) remains in admixture with the gangue in the pulp. To recover this, the pulp is distributed in a thin layer on a shaking table, convex buddle or the like, whereon the mineral is exposed to a free air surface, which exposure may be increased by the application of air blast or air jets or the like, and thereafter brought on to the edge or surface of liquid whereby the metalliferous matter floats and is separated from the gangue which sinks as described in the Specification of our British Application for Patent No. 29,374 of 1904.

The proportion of mineral recovered in the froth and that recovered by table flotation may be considerably varied but generally speaking the froth will separate the slime mineral while the larger particles are recovered by the latter method.

The accompanying drawing is a diagram of one form of apparatus suitable for carrying this invention into practice.

A mixing vessel A (of which there may be any number in series) is provided with a rotatable stirrer B. Crushed ore is fed from a hopper C into the vessel by a band D. A pipe E controlled by a tap E^1 delivers circuit water to the vessel, and oleic acid or other oil is introduced through the pipe F and tap F^1. The outer cock G from the vessel A communicates through a swan-neck pipe H with the froth separating apparatus.

In passing from the frothing apparatus A to the spitzkasten (say between O and K^1) the pulp may if desired be run in a thin layer over a smooth slightly inclined plane and may be submitted to the action of a series of air jets in order to increase the amount of floating metalliferous matter to a maximum.

The froth separating apparatus comprises several (say three) pointed boxes J^1, J^2, J^3 which open at the top into a horizontal channel consisting of side walls K. The channel has a narrow inlet K^1 and spreads out to a wide outlet K^2. The pointed boxes J^1, J^2, J^3 have full-way cocks L^1, L^2, L^3, at the bottom leading to swan-neck

discharge pipes M^1, M^2, M^3. An up-current of water may be led in at the bottom of each box through a tap N^1, N^2, N^3.

The boxes are all filled with circuit water; the pulp from the vessel A is distributed horizontally from the flat trough O through the inlet K^1. The heavy sands and coarser particles of mineral sink into the first box J^1 from which they are led to a shaking table, convex buddle, or the like to be treated as above described. The middlings or medium sands fall into the box J^2 and if they contain any mineral, may be removed for further treatment by agitation. The up-current of water from the taps N^1 N^2 prevents the deposition of any slime in these boxes. The fine sands or gangue slimes settle in the last box J^3 from which they are discharged to waste or further treatment.

The slime mineral in the form of froth or scum floats from the liquid and is carried by the stream over the outlet K^2 into a launder P and thence to a filter Q where the metalliferous matter is removed from the circuit water which is returned to the vessel A by a pump R. The circuit water may be brought to the proper temperature by passing it through a heater S having a burner S^1 before admitting the water to the vessel A.

An alternative method for the recovery of any sunk oiled metalliferous matter which may be deposited in the second and third spitzkasten is as follows: The products suspended in circuit liquor are removed from the spitzkasten and placed in a vessel in 1281 which they are submitted to an additional pressure of air or other gas of from, say, 1 to 2 atmospheres, or over. On relief of such pressure the bubbles of air, or other gas so generated throughout the mass at once sweep to the surface thereof all the metalliferous matter in the form of a froth which can be separated as before.

The nature and arrangement of the apparatus used may be varied without departing from this invention.

Having now particularly described and ascertained the nature of our said invention and in what manner the same is to be performed, we declare that what we claim is:

1. The process of concentrating ores in which finely powdered ore suspended in acidified water is mixed with a small proportion of an oily substance such as oleic acid or petrol amounting to a fraction of 1% on the ore, and agitated until the oil-coated metalliferous matter forms into a froth which can be separated from the gangue by flotation.

2. In the process of concentrating ores covered by Claim 1, warming the pulp (say to 30—40° C) to facilitate the oiling of the metalliferous matter.

3. The process of concentrating ores which consists in agitating the finely powdered ore suspended in acidified water with a small proportion of an oily substance such as oleic acid or petrol amounting to a fraction of 1% on the ore, until the slime mineral forms a froth separating the froth by flotation and separating the coarser mineral from the gangue by exposing them alternately to air and water on a shaking table or the like.

4. The process of concentrating ores which consists in agitating the powdered ore suspended in the water with a small proportion of an oily substance such as oleic acid or petrol amounting to a fraction of 1% on the ore, until the oil-coated slime mineral forms a froth, distributing the mixture on the surface of a current of water running over spitzkasten so that the coarser minerals and sands the finer sands and gangue slimes successively deposit out while the froth is floated away by the current and separated by filtration.

Dated this 2nd day of June, 1905.

HENRY LIVINGSTONE SULMAN.
HUGH FITZALIS KIRKPATRICK PICARD.
JOHN BALLOT.

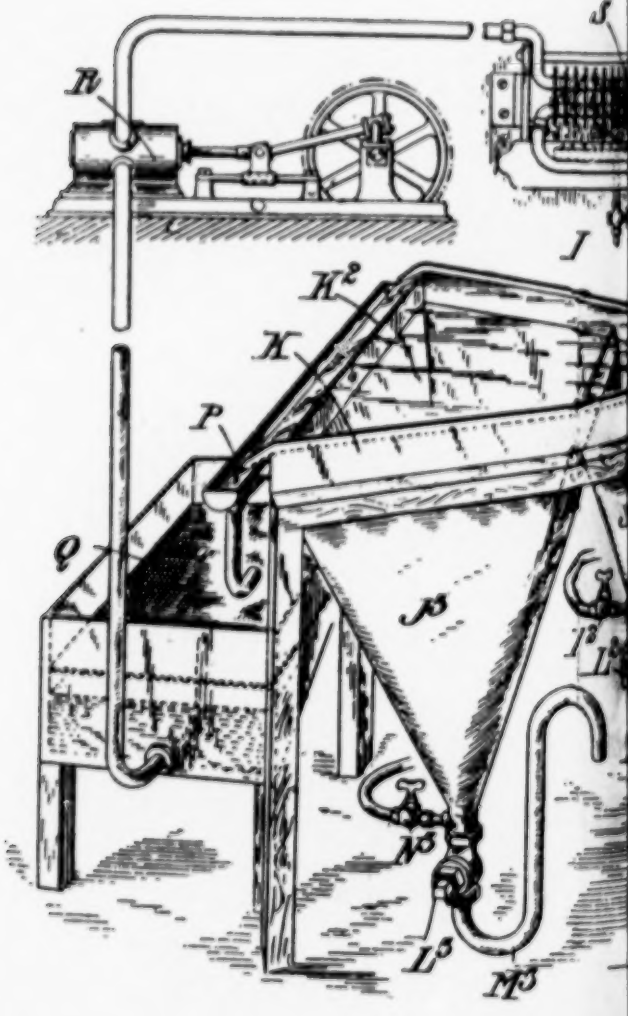
BOULT, WADE & KILBURN,
Agents for the Applicants.

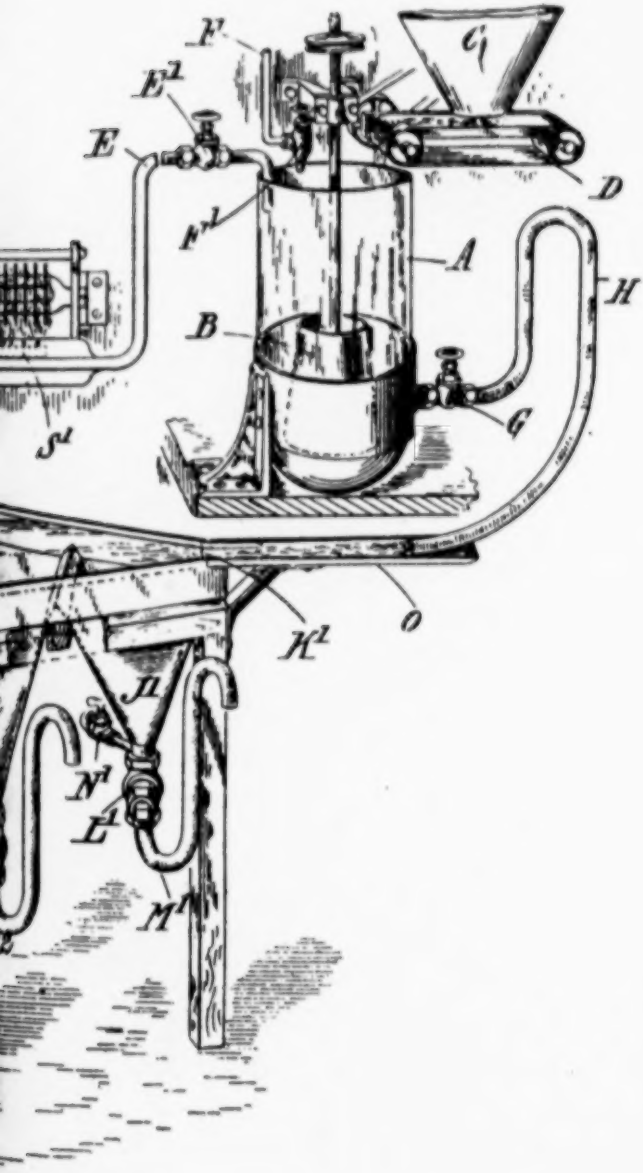
Redhill: Printed for His Majesty's Stationery Office, by Love & Malcomson, Ltd. [G. 9181—125—3'1906]

A.D. 1905 APRIL 12. N.° 7803.

SULMAN & *others'* COMPLETE SPECIFICATION.

(2nd Edition)

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[Second Edition.]

1283

N° 17,328 A.D. 1906

Date of Application, 1st Aug., 1906—Accepted, 25th Oct., 1906

COMPLETE SPECIFICATION.

"Improvements in or relating to Ore Concentration."

(A communication from GEORGE ALBERT CHAPMAN, Metallurgist, of Central Mine, Broken Hill, State of New South Wales, Commonwealth of Australia).

We, MINERALS SEPARATION LIMITED, of 62, London Wall, in the City of London, do hereby declare the nature of this invention and in what manner the same is to be performed to be particularly described and ascertained in and by the following statement:—

This invention relates to improvements in the concentration of ores, the object being to separate metalliferous matter, graphite and the like from gangue by means of oils, fatty acids or other substances which have a preferential affinity for metalliferous matter over gangue.

In the process described in the Specification of British Letters Patent No. 7803 of 1905, granted to Sulman, Picard & Ballot, finely powdered ore, suspended in acidified water, is mixed with a small proportion of an oily substance, such as oleic acid, amounting to a fraction of 1% on the ore, and the whole is agitated until the oil-coated metalliferous matter forms into a froth which can be separated from the gangue by flotation. In the arrangement particularly described for carrying the invention into effect, the ore, oil and acidified water were all mixed together in one agitating vessel and any number of such vessels could be employed in series.

In carrying this process into practice where a number of agitating vessels are used in series, it has now been found that particularly effective results can be obtained if the ore is first agitated with acidified water, say in the first vessel and if the oil is subsequently added, say to a second or following vessel.

Where it is desired to heat the pulp to increase the formation of froth, conveniently the heating can take place after the addition of the oil, for example the pulp may be raised to a suitable temperature when it reaches the third or last agitating vessel of the series.

By thus arranging the sequence of operations, it is found that while the acid strength of the liquor in the first vessel may be say 0·225% acid, the strength in the second vessel is then about 0·05% acid, while in the remaining agitating vessels, in the Spitzkasten feed tanks and other vessels, the acid may be practically or entirely neutralised so that the liquor in circuit as a whole is neutral except at the outset when the ore is introduced.

Having now particularly described and ascertained the nature of the said invention, as communicated to us by our foreign correspondent, and in what manner the same is to be performed, we declare that what we claim is:—

1. The improvement upon the process described in British Patent No. 7803 of 1905, which consists in introducing ore, water and acid into a first agitating vessel and subsequently adding the necessary small proportion of oil or the like in a second or following agitating vessel, substantially as described.

N° 17,328.—A.D. 1906.

Improvements in or relating to Ore Concentration.

2. The improvement upon the process described in British Patent No. 7803 of 1905, which consists in introducing ore, water and acid into a first agitating vessel, subsequently adding the necessary small proportion of oil or the like, say in a second or following agitating vessel, and thereafter heating the mixture in another vessel, substantially as described.

3. The complete improvement upon the process described in British Patent No. 7803 of 1905, substantially as described.

Dated this 1st day of August 1906.

BOULT, WADE & TENNANT
Agents for the Applicant.

Redhill: Printed for His Majesty's Stationery Office, by Love & Malcomson, Ltd.
[Wt. 25—125/L/1906]

N° 23,870 A.D. 1910

Date of Application, 14th Oct, 1910

Complete Specification Left, 6th Apr., 1911—Accepted, 14th Nov, 1911

PROVISIONAL SPECIFICATION.

Improvements in or relating to Ore Concentration.

(Partly communicated from HENRY LAVERS, Metallurgist, of Whittaker Street, Broken Hill, New South Wales)

We, MINERALS SEPARATION LIMITED, and EDWARD HOIT NUTTER, Metallurgist & Mining Engineer, both of 62, London Wall, City of London, do hereby declare the nature of this invention to be as follows.—

This invention is for improvements in or relating to ore concentration by flotation processes and relates more particularly to differential flotation, that is to say, to the separation of different metallic sulphides from one another when flotation processes are used

The processes described in the previous patents relating to the flotation of metalliferous matter in the form of a froth as for example in the Patents Nos. 7803/1905, 26,852/1908, 28,173/1908 and 2359/1909 have hitherto been used in practice for the separation of metallic sulphides from gangue It is now found that by varying certain conditions in the flotation processes a separation can be effected between the different metallic sulphides

It has been observed that when controlling conditions are varied according to this invention the sulphides of various metals have a tendency to float in different ratios to one another This tendency is dependent upon a number of factors, such as the amount and character of the agitation and/or aeration, the chemical constitution of the solution employed, the degree of dilution, the temperature and the amount and nature of the different frothing agents. The word aeration is used in this specification to mean the supplying of air or other gas or gases. We have found that by varying and modifying these factors and conditions we can obtain effective separations between galena and zinc sulphide as well as between other sulphides and metals.

Thus, according to this invention an ore mixed with water and with agents necessary to bring about the formation of a mineral-bearing froth are agitated together with a certain limited degree of agitation and/or aeration so as to cause the flotation of a froth containing the sulphides in a different ratio than obtains in the original ore, or in an ordinary froth. This froth may be removed and re-treated under similar differentiating conditions. This re-treatment may be repeated so as to effect a separation of one sulphide from another.

Or again with an ore or product which contains several mixed sulphides, such for example as an ore containing sulphides of copper, lead and zinc, the agitation of the ore pulp may first be effected with the addition merely of a frothing agent such for example as cresol but without mineral acid whereby a froth is obtained containing mainly copper sulphide, which froth may be re-treated under these differentiating conditions. If the remaining pulp containing the unfloated sulphides is now agitated again with the addition of sulphuric acid as well as the frothing agent, a froth may be obtained containing a larger proportion of lead and finally by the addition of an oily substance

Nº 23,870.—A.D. 1910.

Improvements in or relating to Ore Concentration.

such as oleic acid all the remaining sulphides may be floated, the last froth having a preponderating proportion of zinc sulphide. By varying the conditions under which the float is obtained in this way a series of froths are obtained which differ from one another in their constituents and by re-treatment it is possible to obtain froths containing such a preponderance of one metallic sulphide that the concentrate can be supplied direct to the smelter without further separation of its constituents.

This process can be carried out in an apparatus comprising a series of preliminary mixers connected to spitzkasten or separating boxes for the collection of the froth with successive series of mixers to which the froths are supplied for re-treatment.

There are various well known means of concentrating ores or separating mineral particles of different character as by concentrating tables, vanners, jigs, buddles and various other forms of classifying apparatus depending for their effect upon relative differences in size and specific gravity of the particles or relative differences between the particles as regards falling power in water.

However, efficient separation by these means can generally be obtained only in those cases where a somewhat definite size relationship between the constituents of the product treated already exists or has already been produced by preliminary treatment. In other words an apparatus like a concentrating table or vanner will not effectively treat a complicated product like a crushed ore containing perhaps three or four different metalliferous constituents and one or more gangue constituents all in sizes varying from coarse particles to fine slimes: but if the product be submitted to a preliminary treatment which divides the product into fractions which are simpler and more definite in the size relationship of their constituents, the above methods of ore dressing or separation of mineral particles can be effectively employed on the fractions.

In experimenting with the various known flotation processes of ore treatment—that is to say those processes in which the ore mixed with water containing certain agents is agitated or otherwise treated to cause certain constituents to float in the form of a froth or scum—it is found that when successive froths are produced from a powdered ore (for example by the repeated treatment of the ore pulp under different conditions) the powdered mixtures contained in these successive froths differ widely from the original powdered ore and may differ also from one another as regards the size relationship of their constituents. That is to say if two or more froths are taken from a powdered ore under different conditions, the powdered mixture contained in the first froth may have its constituents in a certain ratio of sizes; the second froth may have its constituents in another ratio of sizes and so on.

The powdered mixture contained in or obtained from each of these froths may now be separately treated on a classifying apparatus such as a concentrating table and an effective separation of the different constituents can be obtained. Such a combination of steps affords means both for the separation of metalliferous matter from gangue and for the separation of different metalliferous ore constituents from one another.

One process therefore of concentrating ores according to this invention consists in treating the crushed ore by a flotation process two or more times under different conditions to obtain froths or scums having the constituents of each in certain ratios of size, and thereafter treating the powdered mixture contained in each froth separately on a classifying apparatus to separate the constituents.

The processes employed to obtain these froths or scums may be any of the well known flotation processes as described for example in Patents Nos. 12,778/02, 29,374/04, 7803/05, 26,852/08, 28,173/08, 2359/09 *etcetera*.

The classifying apparatus employed may be concentrating tables, vanners, buddles or the like.

Nº 23,870.—A.D. 1910.

Improvements in or relating to Ore Concentration.

The following are examples of applications of this invention:

In the case of an ore containing gangue and sulphides of copper and zinc, if the crushed ore is agitated with water containing a minute proportion of a frothing agent such for example as cresol or eucalyptus oil (but without the use of any acid), the froth produced may contain a proportion of the copper minerals, some comparatively fine zinc and some still finer gangue. If the remaining pulp is heated and a small amount of sulphuric acid is added another float can be taken off which will have a greater proportion of coarser zinc and copper in it than in the first float and in general the zinc will be finer than the copper. If oleic acid is added and another froth taken after the usual agitation the remaining metalliferous constituents will be floated containing much of the coarsest material. The bulk of the gangue will remain unfloated.

These froths could then be treated separately and independently by vanning machines or concentrating tables and a separation as between the different metalliferous constituents present could be better obtained than if the whole metalliferous contents were obtained in one mixed froth and treated together.

In a frothing apparatus of the general type described in the previous Application No. 6896/1910 the formation of a froth can be effected under different conditions in the different agitators. The various froths can be collected from the different mixers or the different spitzkasten separately and the powdered mixtures obtained from these froths can be treated separately on concentrating tables or the like to obtain an effective separation of the constituents.

In some cases by varying the conditions under which the various froths are formed, the froths obtained will differ from one another both as regards their constituents and as regards their range of size and this invention includes the treatment of a complex ore or product by taking from it two or more froths under different conditions as described so as to obtain froths differing from one another in their character and thereafter re-treating the froths so as to effect a substantial separation of one metalliferous constituent of the ore from another.

Dated this 14th day of October, 1910.

BOULT, WADE & TENNANT,
111/112, Hatton Garden, London, E.C.,
Chartered Patent Agents.

COMPLETE SPECIFICATION.

Improvements in or relating to Ore Concentration.

We, MINERALS SEPARATION LIMITED, and EDWARD HOIT NUTTER, Metallurgist and Mining Engineer, both of 62, London Wall, City of London, do hereby declare the nature of this invention and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement:—

This invention is for improvements in or relating to ore concentration by flotation processes and relates more particularly to differential flotation, that is to say, to the separation of different metallic sulphides from one another when flotation processes are used.

The processes described in the previous patents relating to the flotation of metalliferous matter in the form of a froth as for example in the Patents Nos. 7803/1905, 26,852/1908, 28,173/1908 and 2359/1909 have hitherto been used in practice for the separation of metallic sulphides from gangue. It is now found that by varying certain conditions in the flotation processes a separation can be effected between the different metallic sulphides.

N° 23,870.—A.D. 1910.

Improvements in or relating to Ore Concentration

It has been observed that when controlling conditions are varied according to this invention the sulphides of various metals have a tendency to float in different ratios to one another. This tendency is dependent upon a number of factors, such as the amount and character of the agitation and/or aeration, the chemical constitution of the solution employed, the degree of dilution, the temperature and the amount and nature of the different frothing agents. The word aeration is used in this specification to mean the supplying of air or other gas or gases. We have found that by varying and modifying these factors and conditions we can obtain effective separations between galena and zinc sulphide as well as between other sulphides and metals.

Thus according to this invention an ore mixed with water and with agents necessary to bring about the formation of a mineral-bearing froth are agitated together with a certain limited degree of agitation and/or aeration so as to cause the flotation of a froth containing the sulphides in a different ratio than obtains in the original ore, or in an ordinary froth. This froth may be removed and re-treated under similar differentiating conditions. This re-treatment may be repeated so as to effect a separation of one sulphide from another.

Or again with an ore or product which contains several mixed sulphides, such for example as an ore containing sulphides of copper, lead and zinc, the agitation of the ore pulp may first be effected with the addition merely of a frothing agent such for example as cresol but without mineral acid whereby a froth is obtained containing mainly copper sulphide, which froth may be re-treated under these differentiating conditions. If the remaining pulp containing the unfloated sulphides is now agitated again with the addition of sulphuric acid as well as the frothing agent, a froth may be obtained containing a larger proportion of lead and finally by the addition of an oily substance such as oleic acid all the remaining sulphides may be floated, the last froth having a preponderating proportion of zinc sulphide. By varying the conditions under which the float is obtained in this way a series of froths are obtained which differ from one another in their constituents and by re-treatment it is possible to obtain froths containing such a preponderance of one metallic sulphide that the concentrate can be supplied direct to the smelter without further separation of its constituents.

This process can be carried out in an apparatus comprising a series of preliminary mixers connected to spitzkasten or separating boxes for the collection of the froth with successive series of mixers to which the froths are supplied for re-treatment.

There are various well known means of concentrating ores or separating mineral particles of different character as by concentrating tables, vanners jigs, buddles and various other forms of classifying apparatus depending for their effect upon relative differences in size and specific gravity of the particles or relative differences between the particles as regards falling power in water.

However, efficient separation by these means can generally be obtained only in those cases where a somewhat definite size relationship between the constituents of the product treated already exists or has already been produced by preliminary treatment. In other words an apparatus like a concentrating table or vanner will not effectively treat a complicated product like a crushed ore containing perhaps three or four different metalliferous constituents and one or more gangue constituents all in sizes varying from coarse particles to fine slimes; but if the product be submitted to a preliminary treatment which divides the product into fractions which are simpler and more definite in the size relationship of their constituents, the above methods of ore dressing or separation of mineral particles can be effectively employed on the fractions.

In experimenting with the various known flotation processes of ore treatment—that is to say those processes in which the ore mixed with water containing certain agents is agitated or otherwise treated to cause certain

Nº 23,870.—A.D. 1910.

Improvements in or relating to Ore Concentration.

constituents to float in the form of a froth or scum—it is found that when successive froths are produced from a powdered ore (for example by the repeated treatment of the ore pulp under different conditions) the powdered mixtures contained in these successive froths differ widely from the original powdered ore and may differ also from one another as regards the size relationship of their constituents. That is to say if two or more froths are taken from a powdered ore under different conditions, the powdered mixture contained in the first froth may have its constituents in a certain ratio of sizes; the second froth may have its constituents in another ratio of sizes and so on.

The powdered mixture contained in or obtained from each of these froths may now be separately treated on a classifying apparatus such as a concentrating table and an effective separation of the different constituents can be obtained. Such a combination of steps affords means both for the separation of metalliferous matter from gangue and for the separation of different metalliferous ore constituents from one another.

One process therefore of concentrating ores according to this invention consists in treating the crushed ore by a flotation process two or more times under different conditions to obtain froths or scums having the constituents of each in certain ratios of size, and thereafter treating the powdered mixture contained in each froth separately on a classifying apparatus to separate the constituents.

The processes employed to obtain these froths or scums may be any of the well known flotation processes as described for example in Patents Nos. 12,778/02, 29,374/04, 7803/05, 26,852/08, 28,173/08, 2359/09 *etcetera*.

The classifying apparatus employed may be concentrating tables, vanners, buddles or the like.

The following are examples of applications of this invention:—

In the case of an ore containing gangue and sulphides of copper and zinc, if the crushed ore is agitated with water containing a minute proportion of a frothing agent such for example as cresol or eucalyptus oil (but without the use of any acid), the froth produced may contain a proportion of the copper minerals, some comparatively fine-zinc and some still finer gangue. If the remaining pulp is heated and a small amount of sulphuric acid is added another float can be taken off which will have a greater proportion of coarser zinc and copper in it than in the first float and in general the zinc will be finer than the copper. If oleic acid is added and another froth taken after the usual agitation the remaining metalliferous constituents will be floated containing much of the coarsest material. The bulk of the gangue will remain unfloated.

These froths could then be treated separately and independently by vanning machines or concentrating tables and separation as between the different metalliferous constituents present could be better obtained than if the whole metalliferous contents were obtained in one mixed froth and treated together.

In a frothing apparatus of the general type described in the previous Application No. 6896/1910 or in the concurrent Application No. 23,949/1910 the formation of a froth can be effected under different conditions in the different agitators. The various froths can be collected from the different mixers or the different spitzkasten separately and the powdered mixtures obtained from these froths can be treated separately on concentrating tables or the like to obtain an effective separation of the constituents.

In some cases by varying the conditions under which the various froths are formed, the froths obtained will differ from one another both as regards their constituents and as regards their range of size and this invention includes the treatment of a complex ore or product by taking from it two or more froths under different conditions as described so as to obtain froths differing from one another in their character and thereafter re-treating the froths so as to effect a substantial separation of one metalliferous constituent of the ore from another.

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Improvements in or relating to Ore Concentration.

Having now particularly described and ascertained the nature of our said invention and in what manner the same is to be performed, as communicated to us by our foreign correspondent, we declare that what we claim is:—

1. The herein described process of concentrating ores which consists in mixing the ore with water and with agents necessary to bring about the formation of a mineral bearing froth, agitating the pulp with a certain limited degree of agitation and/or aeration so as to cause the flotation of a froth containing the sulphides in a different ratio than obtains in the original ore or in an ordinary froth, removing the froth and retreating it under similar differentiating conditions.

2. The herein-described process of concentrating ores which consists in agitating the ore with water containing one mineral frothing agent so as to yield a certain froth containing a fraction of the floatable minerals and removing the froth, agitating the pulp again with the addition of another agent which results in the production of another froth containing a second fraction of the flotable mineral and so on, substantially as described.

3. The herein described process of concentrating ores which consists in agitating the ore pulp first with the addition merely of a mineral-frothing agent but without mineral acid and removing the froth agitating the remaining pulp again with the addition of mineral acid as well as the mineral-frothing agent, removing the froth and thereafter agitating the pulp again with the addition of an oily substance such as oleic acid and removing the froth, each of which froths may be re-treated under differentiating conditions.

4. The herein-described process for concentrating ores which consists in treating the crushed ore by a flotation process two or more times under different conditions to obtain froths or scums having the constituents of each in certain ratios of size, and thereafter treating the powdered mixture contained in each froth separately by a classifying apparatus to separate the constituents.

5. The complete process for concentrating ores substantially as described.

Dated this 6th day of April, 1911.

BOULT, WADE & TENNANT,
111 & 112, Hatton Garden, London, E.C.,
Chartered Patent Agents.

Redhill: Printed for His Majesty's Stationery Office, by Love & Malcomson, Ltd.—1913.

N° 23,949 A.D. 1910

Date of Application, 15th Oct., 1910

Complete Specification Left, 18th Apr., 1911—Accepted, 15th Nov., 1911

PROVISIONAL SPECIFICATION.

Improvements in or relating to Method and Apparatus for Ore Concentration.

We, EDWARD HOIT NUTTER, Metallurgist and Mining Engineer, and THEODORE JESSE HOOVER, Metallurgist and Consulting Engineer, and MINERALS SEPARATION LIMITED, all of 62, London Wall, in the City of London, do hereby declare the nature of our invention to be as follows:—

This invention is for improvements in or relating to method and apparatus for ore concentration.

Several processes are known in which certain particles are raised to the surface of a liquid containing powdered ore in suspension, by means of bubbles of air or gas that have been caused to attach themselves to these certain particles which are thereby caused to float, while other particles are not so floated. Thus the powdered ore mixed with water containing a mineral-frothing agent may be agitated so as to beat air into the liquid and form a coherent froth by which certain constituents of the ore such as metallic sulphides are floated. One object of this invention is to improve the apparatus used in this type of process, and apparatus constructed in accordance with this invention is applicable for use in any of the well known froth flotation processes of ore concentration.

In apparatus at present in use in which a mineral bearing froth is formed and collected it is customary for the froth to be removed from the main pulp after the froth has reached a free air surface so that if the gaseous bubbles or some of them burst on reaching the free air surface there is a possibility that some of the mineral contents of the froth will fall back into the pulp or circuit liquor and fail to be separated and this does in fact occur.

According to this invention a method of ore concentration by the formation of a mineral bearing froth consists in causing the froth as it is formed to fall over a trap, baffle or wall below the level of the free air surface whereby the froth is collected and removed from the pulp before the bubbles can burst.

An apparatus for concentrating ores by gaseous flotation of certain mineral particles in liquid according to this invention comprises the combination with an agitating vessel in which the liquid containing a mineral-frothing agent and containing powdered ore in suspension is agitated so as to beat air into it, of a conduit through which the froth passes and a "trap" to catch the froth before the bubbles reach a free air surface whereby the froth is collected and removed from the pulp.

Thus the conduit through which the froth is caused to pass may have a wall, partition, or lip the top of which is below the normal surface of the froth or at any rate below the free air surface of the froth whereby the froth falls over the wall or lip and is trapped before the bubbles in the froth can burst so that the mineral contents of the bubbles which burst are discharged into the trap compartment and not into the pulp. It is possible to arrange that the froth passes directly out of the mixing vessel and over a lip or trap which is below a free air surface and over which the froth passes whereby the froth is collected immediately after it is formed and removed from the pulp before the bubbles can reach the free air surface and burst.

[*Price* 8*d*.]

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Improvements in or relating to Method and Apparatus for Ore Concentration.

A feature of this invention consists in the combination with two or more mixing vessels of a passage or separate compartment through which the ore pulp travels in passing from one vessel to the other and a froth conduit from said passage or compartment so that the froth is led away and trapped while the pulp is passing from one vessel to another. A practical form of this apparatus comprises a number of mixing and separating vessels substantially on the same level. Passages outside the vessels or separate intermediate compartments connect each vessel with the adjacent vessel and a froth conduit and trap are arranged at each passage or intermediate compartment whereby the froth formed at each stage of the agitation is led away and trapped while the pulp passes through the series of mixing vessels, passages or compartments.

In any of the arrangements described above this invention includes the combination with a first lip which is below the free air surface and over which the whole froth passes into a trap of a second lip over which the more permanent froth passes from the trap into a launder or other collector, and various arrangements may be used for removing the concentrates that sink to the bottom of the trap compartment.

The following is a description by way of example of one form of apparatus embodying this invention:—

Several mixing vessels are placed side by side on the same level. These may conveniently be vats separated by partitions. Each vessel is provided with a rotatable agitator or stirrer carried by a vertical spindle rotated at a high speed by any convenient means.

The first vessel is connected to the second, the second to the third, the third to the fourth and so on by passages and compartments outside the mixing vessels lying along one side of the mixing vessels or between them and on the same level with them. By this arrangement the pulp passes from the first vessel through the connecting passage or compartment to the second vessel and so on, and at the end of the series the pulp may conveniently be passed into a spitzkasten as described in the previous British Patent No. 4911/1909 for example.

At each connecting passage or compartment there is a froth trap, that is to say, baffles or conduits are so arranged in connection with these passages that the mineral-bearing bubbles in rising are directed into a separate compartment from that through which the main circuit passes before the bubbles reach the free air surface and have a chance to break. Thus, for example, a wall of each connecting passage may be formed by a partition the top or lip of which is below the level of the free air surface of the froth when the apparatus is working. The froth rises in the connecting passage and a roof or cover is provided to lead the froth over the lip or partition before the bubbles get to a free air surface. Outside the lip or partition is a trap compartment into which the mineral-bearing froth falls or passes. The froth reaches a free air surface in this trap compartment and the bubbles which burst deposit the mineral in the trap compartment. The outer wall of the trap compartment may comprise a second lip higher than the first; and the more permanent froth will collect in the trap compartment and flow over the second lip into a launder and in most cases it will be found that the froth passing into the launder will carry the cleanest concentrate.

Any suitable means may be employed for removing the mineral from the trap compartment. If the mineral is not a clean concentrate or if it contains mixed minerals it may be re-treated conveniently in an apparatus similar to the one just described. It will be seen that the apparatus can be made in an extremely compact form as the pulp remains substantially on the same level throughout.

The apparatus affords a solution of many problems. There are many ores which are poor in sulphides, or which do not readily froth or which form a froth which is tender. The tendency in such cases is for the bubbles to break as the froth reaches the surface of the pulp and for part of the mineral to sink

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Improvements in or relating to Method and Apparatus for Ore Concentration.

back into the pulp. With some frothing agents it is quite possible to get the mineral to the surface but a permanent froth is not usually formed but by the use of the apparatus embodying this invention substantially all the mineral which is floated is collected. With the frothing apparatus at present in use the froth does not have an opportunity of separating until the pulp as a whole has undergone a certain period of agitation. With some frothing agents the normal agitation is too long that is to say mineral-bearing froth formed during the commencement of the agitation is destroyed again before the froth has an opportunity of separating. With the present apparatus however the froth will come off and be trapped immediately after it is formed.

Another important problem was to provide a plant which will lend itself to the separation of the different metalliferous constituents of an ore by differential flotation In the Patent Application No 23,870 of 1910 is described a process of obtaining successive mineral bearing froths and by conducting the mixing operation under varying conditions and thereafter treating the different froths again under differentiating conditions.

The apparatus embodying this invention affords ready means for carrying out such a process as the froth may be trapped, re-treated and trapped again exactly at the stages required for differentiating between the different floatable constituents

The details of the apparatus may be varied without departing from this invention, thus the form of the conduit through which the froth passes away from the pulp may be widely varied as such conduit may be formed by suitably directed baffles, walls, tubes and the like The method of conveying the mineral from the trap compartment may be by spitzluten, by continuous water flow, by positive conveyor, by automatic valve or otherwise.

Dated this 15th day of October, 1910.

BOULT, WADE & TENNANT,
111/112, Hatton Garden, London, E C.
Chartered Patent Agents.

COMPLETE SPECIFICATION

Improvements in or relating to Method and Apparatus for Ore Concentration.

We, EDWARD HOIT NUTTER, Metallurgist and Mining Engineer, and THEODORE JESSE HOOVER, Metallurgist and Consulting Engineer, and MINERALS SEPARATION LIMITED, all of 62, London Wall, in the City of London, do hereby declare the nature of this invention and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement:—

This invention is for improvements in or relating to a method and apparatus for ore concentration.

Several processes are known in which certain particles are raised to the surface of a liquid containing powdered ore in suspension, by means of bubbles of air or gas that have been caused to attach themselves to those certain particles which are thereby caused to float, while other particles are not so floated Thus the powdered ore mixed with water containing a mineral-frothing agent may be agitated so as to beat air into the liquid and form a coherent froth by which certain constituents of the ore such as metallic sulphides are floated One object of this invention is to improve the apparatus used in this type of process, and apparatus constructed in accordance with this invention is applicable for use in any of the well known froth flotation processes of ore concentration

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Improvements in or relating to Method and Apparatus for Ore Concentration.

In apparatus at present in use in which a mineral bearing froth is formed and collected it is customary for the froth to be removed from the main pulp after the froth has reached a free air surface so that if the gaseous bubbles or some of them burst on reaching the free air surface there is a possibility that some of the mineral contents of the froth will fall back into the pulp or circuit liquor and fail to be separated and this does in fact occur.

According to this invention a method of ore concentration by the formation of a mineral bearing froth consists in causing the froth as it is formed to fall over a trap, baffle or wall below the level of the free air surface whereby the froth is collected and removed from the pulp before the bubbles can burst.

An apparatus for concentrating ores by gaseous flotation of certain mineral particles in liquid according to this invention comprises the combination with an agitating vessel in which the liquid containing a mineral-frothing agent and containing powdered ore in suspension is agitated so as to beat air into it, of a conduit through which the froth passes and a "trap" to catch the froth before or as the bubbles reach a free air surface whereby the froth is collected and removed from the pulp.

Thus the conduit through which the froth is caused to pass may have a wall, partition, or lip the top of which is below the normal surface of the froth or at any rate below the free air surface of the froth whereby the froth falls over the wall or lip and is trapped before the bubbles in the froth can burst so that the mineral contents of the bubbles which burst are discharged into the trap compartment and not into the pulp. It is possible to arrange that the froth passes directly out of the mixing vessel and over a lip or trap which is below a free air surface and over which the froth passes whereby the froth is collected immediately after it is formed and removed from the pulp before the bubbles can reach the free air surface and burst.

A feature of this invention consists in the combination with two or more mixing vessels of a passage or separate compartment through which the ore pulp travels in passing from one vessel to the other and a froth conduit from said passage or compartment so that the froth is led away and trapped while the pulp is passing from one vessel to another. A practical form of this apparatus comprises a number of mixing and separating vessels substantially on the same level. Passages outside the vessels or separate intermediate compartments connect each vessel with the adjacent vessel and a froth conduit and trap are arranged at each passage or intermediate compartment whereby the froth formed at each stage of the agitation is led away and trapped while the pulp passes through the series of mixing vessels, passages or compartments. The mixing vessels may be connected together in pairs by orifices in the partitions between them, and the passages outside the vessels may be arranged to connect one vessel of each pair with the adjacent vessel of the next pair, a froth trap being placed at each passage.

In any of the arrangements described above this invention includes the combination with a first lip which is below the free air surface and over which the whole froth passes into a trap of a second lip over which the more permanent froth passes from the trap into a launder or other collector, and various arrangements may be used for removing the concentrates that sink to the bottom of the trap compartment.

In the accompanying drawings which illustrate by way of example one form of apparatus embodying this invention,

Figure 1 is a front elevation partly in section,

Figure 2 is a transverse section, and

Figure 3 is a plan of the apparatus.

Several mixing vessels A are placed side by side on the same level. Each vessel is provided with a rotatable agitator or stirrer A^1 carried by a vertical spindle A^2 rotated at a high speed by any convenient means. The first vessel

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Improvements in or relating to Method and Apparatus for Ore Concentration.

is connected with the second, the second to the third, the third to the fourth and so on by passages or compartments B between the mixing vessels and on the same level with them. By this arrangement the pulp passes from the first vessel A through the connecting passage or compartment B to the second vessel A and so on and at the end of the series the pulp may conveniently be passed into a spitzkasten as described in the previous British Patent No. 4911 of 1909 for example.

At each connecting passage or compartment B there is a froth trap, that is to say baffles or conduits are so arranged in connection with these passages that the mineral-bearing bubbles in rising are directed into a separate compartment from that through which the main circuit passes, before the bubbles reach the free air surface and have a chance to break. Thus, for example, the wall of each connecting passage B may be formed by a partition D the top or lip D^1 of which is below the level of the free air surface of the froth when the apparatus is working.

The froth rises in the connecting passage B and a roof or cover E is provided to lead the froth over the lip or partition D before the bubbles get to a free air surface. Outside the lip or partition is a trap compartment F into which the mineral-bearing froth falls or passes. The froth reaches a free air surface in this trap compartment F and the bubbles which burst deposit the mineral in the trap compartment. The outer wall G of the trap compartment may comprise a second lip G^1 higher than the first; and the more permanent froth will collect in the trap compartment F and flow over the second lip G^1 into a launder H and in most cases it will be found that the froth passing into the launder will carry the cleanest concentrate.

Any suitable means may be employed for removing the mineral from the trap compartment. If the mineral is not a clean concentrate or if it contains mixed minerals it may be re-treated conveniently in an apparatus similar to the one just described. It will be seen that the apparatus can be made in an extremely compact form as the pulp remains substantially on the same level, throughout.

The apparatus affords a solution of many problems. There are many ores which are poor in sulphides, or which do not readily froth or which form a froth which is tender. The tendency in such cases is for the bubbles to break as the froth reaches the surface of the pulp and for part of the mineral to sink back into the pulp. With some frothing agents it is quite possible to get the mineral to the surface but a permanent froth is not usually formed but by the use of the apparatus embodying this invention substantially all the mineral which is floated is collected. With the frothing apparatus at present in use the froth does not have an opportunity of separating until the pulp as a whole has undergone a certain period of agitation. With some frothing agents the normal agitation is too long that is to say mineral-bearing froth formed during the commencement of the agitation is destroyed again before the froth has an opportunity of separating. With the present apparatus however the froth will come off and be trapped immediately after it is formed.

Another important problem was to provide a plant which will lend itself to the separation of the different metalliferous constituents of an ore by differential flotation. In the Patent Application No. 23,870 of 1910 is described a process of obtaining successive mineral bearing froths and by conducting the mixing operation under varying conditions and thereafter treating the different froths again under differentiating conditions.

The apparatus embodying this invention affords ready means for carrying out such a process as the froth may be trapped, re-treated and trapped again exactly at the stages required for differentiating between the different flotable constituents.

The details of the apparatus may be varied without departing from this invention, thus the form of the conduit through which the froth passes away from the

pulp may be widely varied as such conduit may be formed by suitably directed baffles, walls, tubes and the like. The method of conveying the mineral from the trap compartment may be by spitzluten, by continuous water flow, by positive conveyor, by automatic valve or otherwise.

Having now particularly described and ascertained the nature of our said invention and in what manner the same is to be performed, we declare that what we claim is:—

1. In an apparatus for concentrating ores by gaseous flotation of certain mineral particles in liquid, the combination with an agitating vessel in which the liquid containing powdered ore in suspension is agitated so as to beat air into it, of a conduit through which the froth passes and a "trap" to catch the froth before or as the bubbles reach the liquid surface whereby the froth is collected and removed from the pulp.

2. A method of ore concentration by the formation of a mineral bearing froth which consists in causing the froth as it is formed to fall over a trap or wall below the level of the free air surface whereby the froth is collected and removed from the pulp before the bubbles can burst.

3. In an apparatus for concentrating ores by gaseous flotation of certain mineral particles in liquid the combination with two mixing vessels of a passage which conveys the ore pulp from one vessel to another and a froth conduit from the passage whereby the froth is led away and trapped substantially as described.

4. A practical form of apparatus of the kind described for concentrating ores by gaseous flotation of certain mineral particles in liquid comprising a number of mixing vessels substantially on the same level connected together in pairs by orifices in the partitions between them and passages outside the vessels connecting one vessel of each pair with the adjacent vessel of the next pair and a froth trap at each passage whereby the froth formed at each stage of the agitation is led away and trapped while the pulp passes through the series of mixing vessels.

5. In an apparatus as covered in any of the preceding claims the combination with a first lip which is below the free air surface and over which the whole froth passes into a trap of a second lip over which the more permanent froth passes into a launder or other collector.

Dated this 18th day of April, 1911.

BOULT, WADE & TENNANT,
111 & 112, Hatton Garden, London, E.C.,
Chartered Patent Agents.

Redhill: Printed for His Majesty's Stationery Office, by Love & Malcomson, Ltd.—1911.

A.D. 1910, Oct. 15. Nº 23,949.
NUTTER & *others'* Complete Specification.

[This Drawing is a reproduction of the Original on a reduced scale]

Fig. 1.

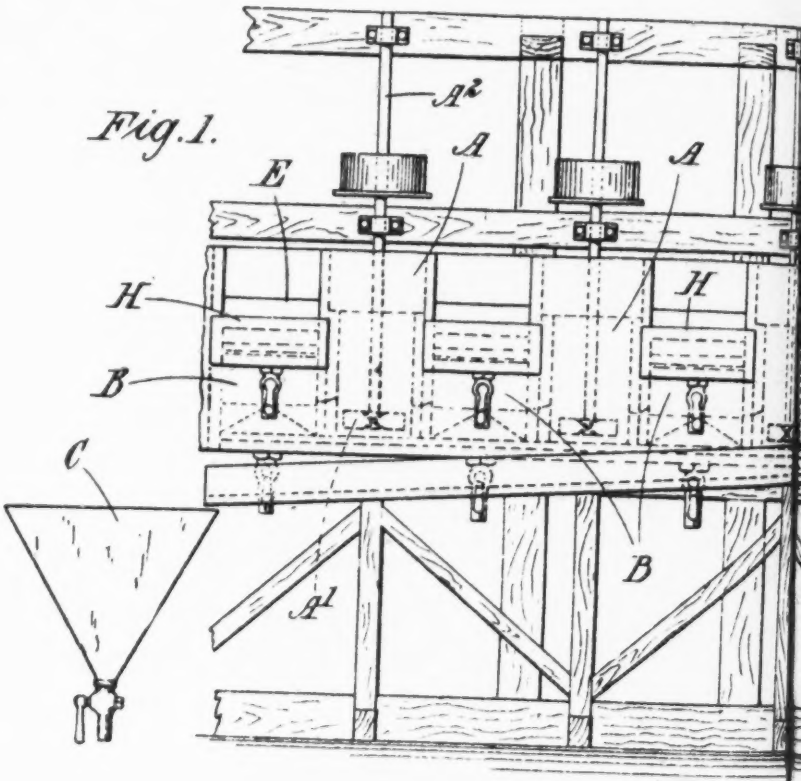
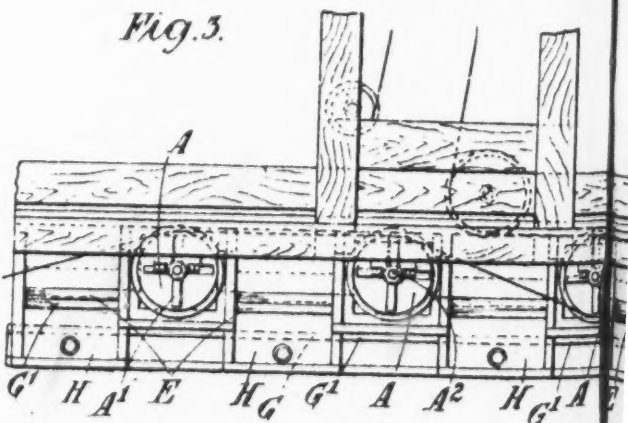


Fig. 3.



(1 SHEET)

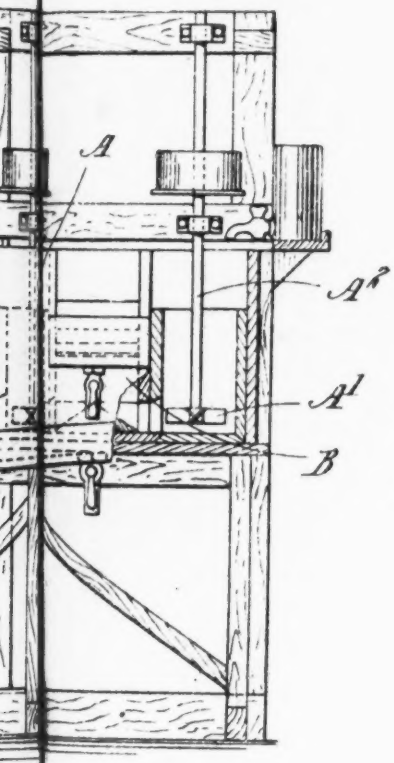
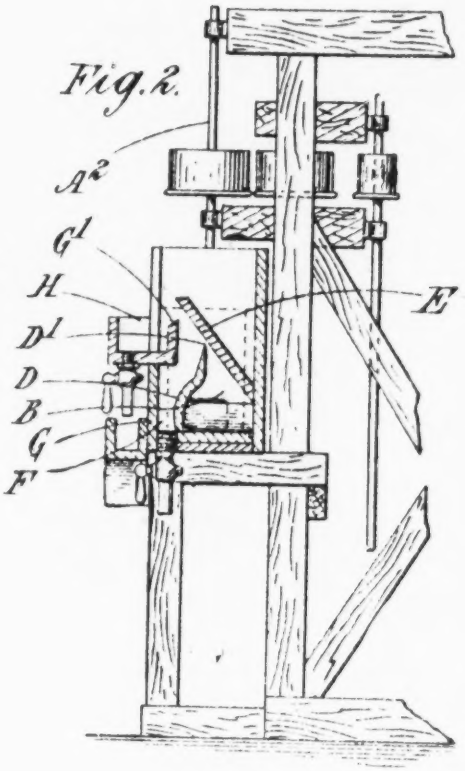
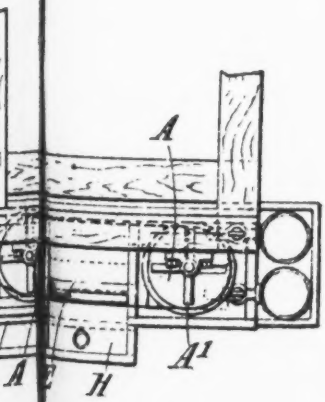
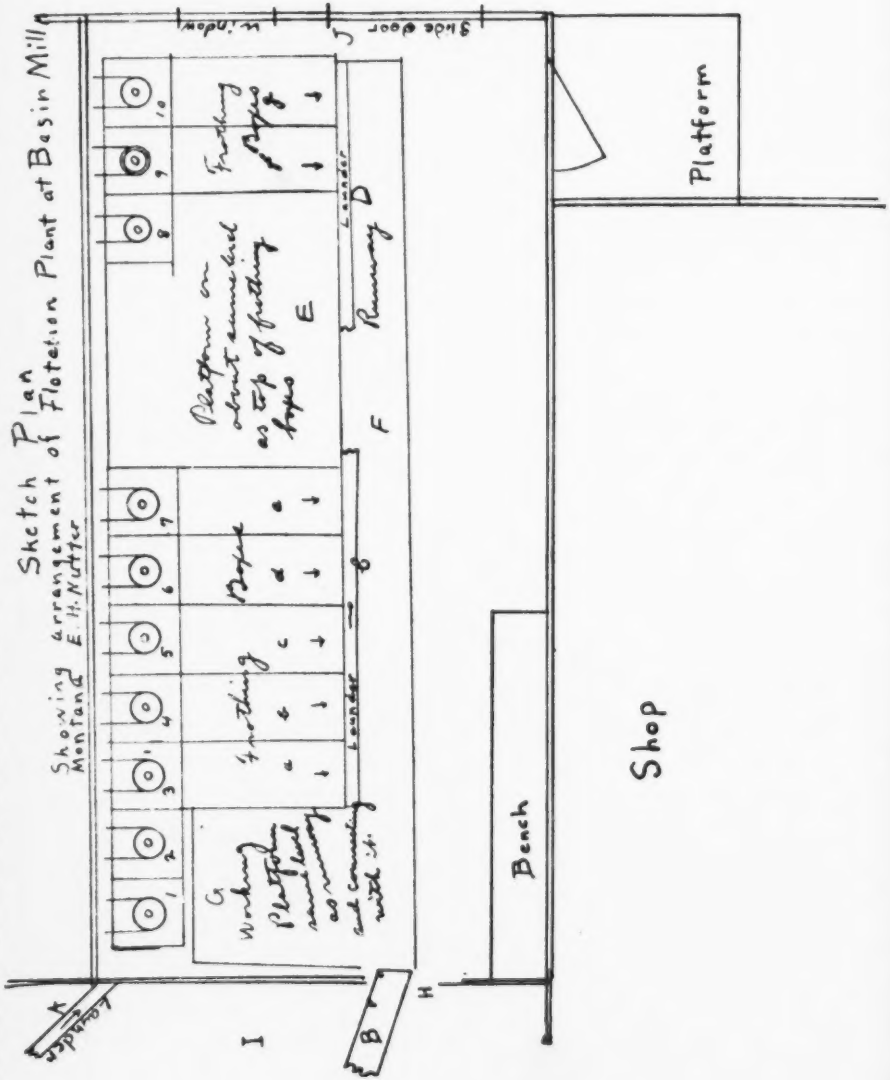


Fig. 2.





COMPLAINANTS' EXHIBIT, NUTTER DRAWING DEFENDANT'S PLANT (Sheet 1).



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COMPLAINANTS' EXHIBIT, NUTTER DRAWING DEFENDANT'S PLANT (Sheet 2).

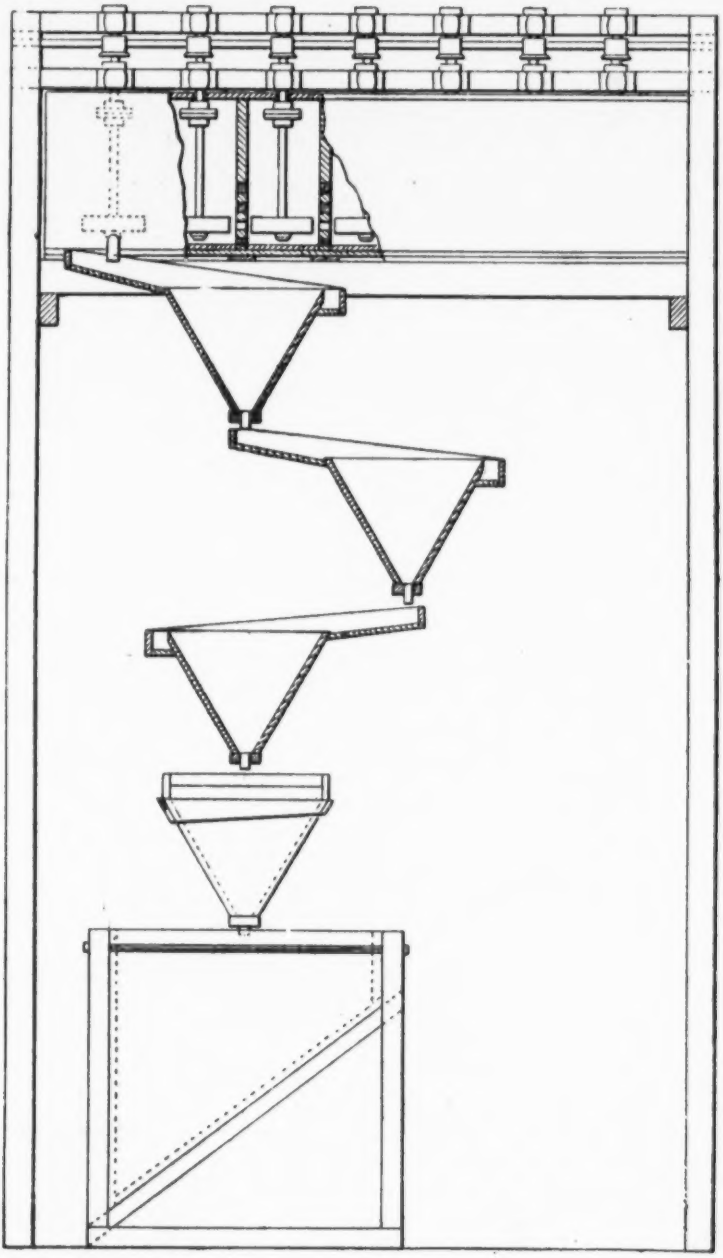
Sketch showing front and end elevations of flotation plant in Bean mill Nuttertown, Mt. Nutter. Figures and letters refer to same reference value in all sketches. Broken lines indicate the extension of runways, framework carrying agitator bearings, etc. If different than shown do not otherwise it clearly. Crosses indicate shaft bearings.

1302

Complainants' Exhibit
Sulman Drawing accompanying Report - May 3, 1905.
Diagrammatic sketch of plant arranged for 0.1 - 0.2 % Oleic acid process
Diagram accompanying Supt's Report 4/5/05
Pump
Heater for return circuit
Compound Settling tank
No 1
No 2
No 3
fine Sands
Gauged Slimes
Mineral / Froth
Settler
Circuit Water Sump
Launder
Series of 4 glass gasholds - designed to give 8 minutes Agitation to charge Aerating Trough
Aeration Table
Mineral Concentrates Ready for treating down Launder
Tyrrel Coarse Sands
ORE-BIN

1303

COMPLAINANTS EXHIBIT DRAWING AUSTRALIAN MODEL PLANT

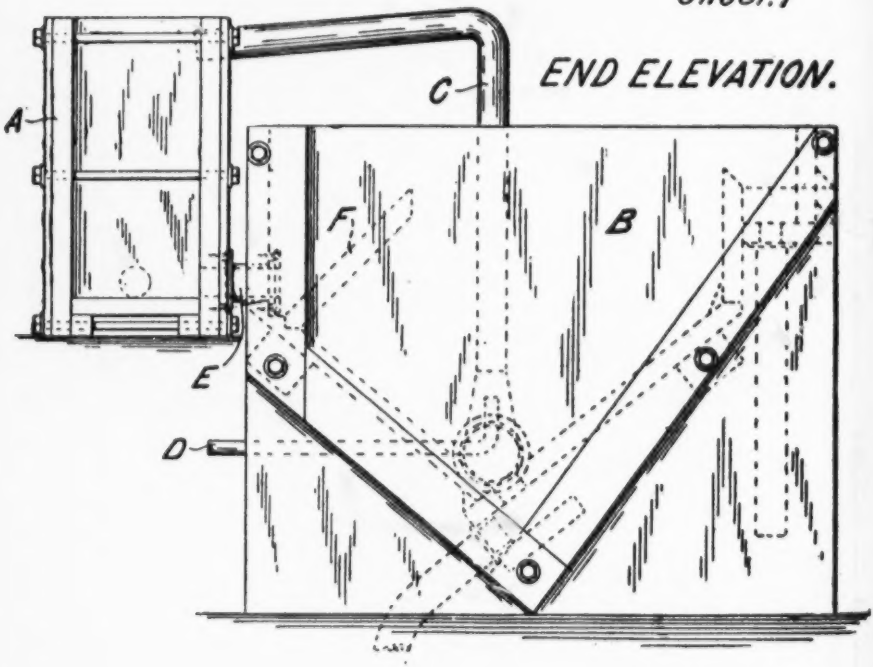


1304

COMPLAINANTS EXHIBIT DRAWING OF
1909 AND 1910 AGITATION-FROTH PLANTS.
— THE EMU PLANT AND LAST —
CHARLOTTE STREET PLANT.

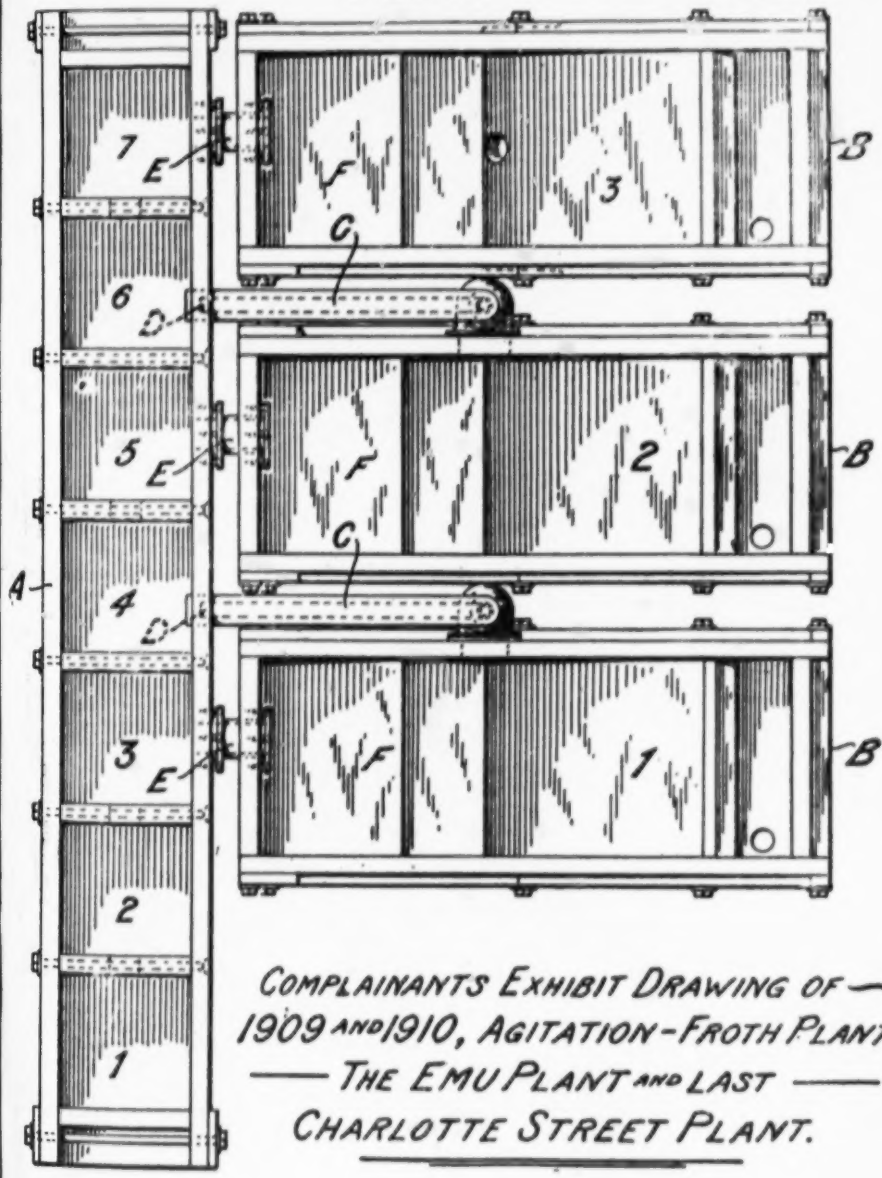
Sheet. 1

END ELEVATION.



1305

PLAN. Sheet. 2.

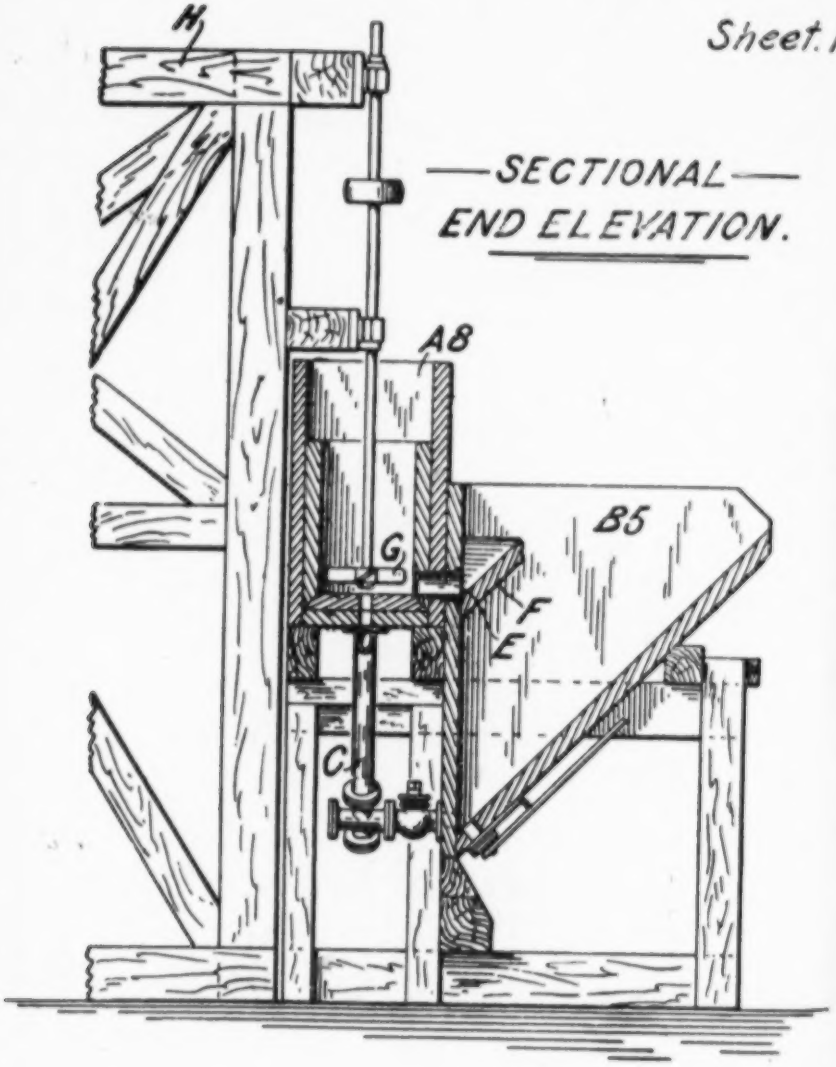


COMPLAINANTS EXHIBIT DRAWING OF — 1909 AND 1910, AGITATION-FROTH PLANTS. — THE EMU PLANT AND LAST — CHARLOTTE STREET PLANT.

— COMPLAINANTS EXHIBIT —

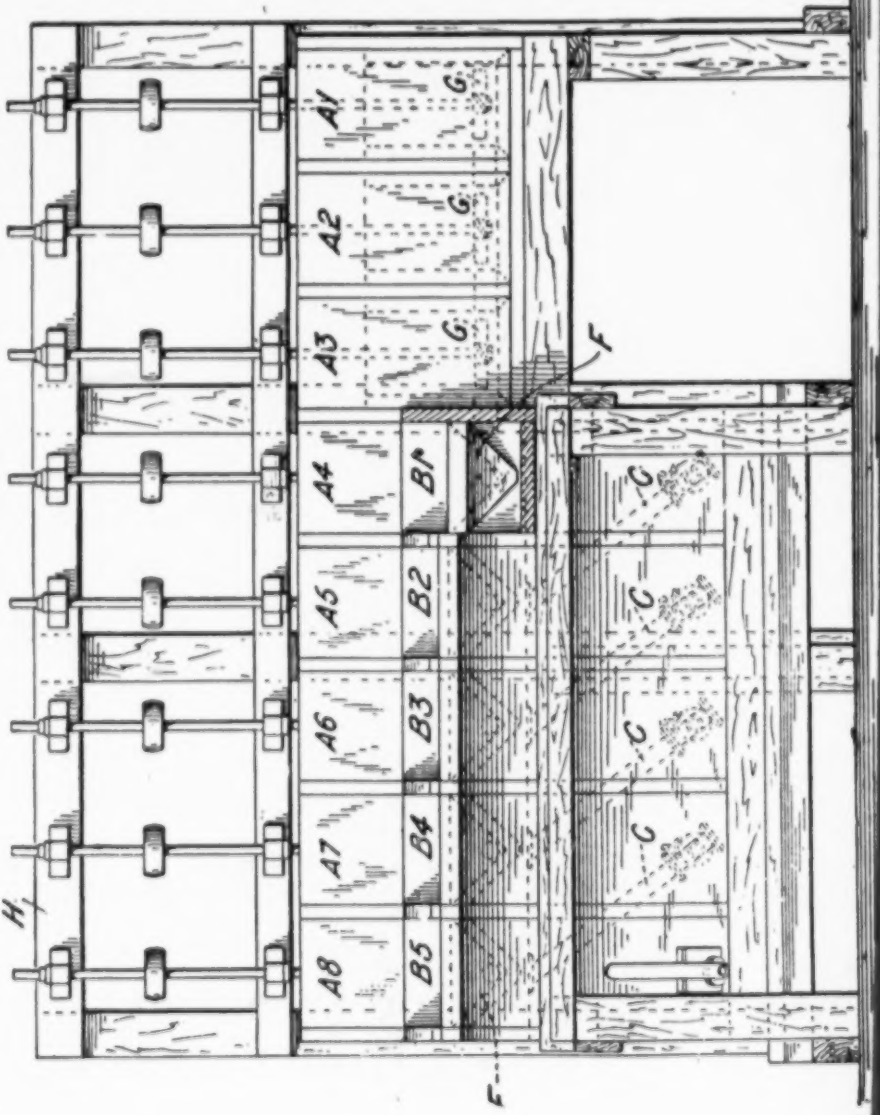
KING JOHN'S COURT STANDARD PLANT.

Sheet. 1.



— SECTIONAL —
END ELEVATION.

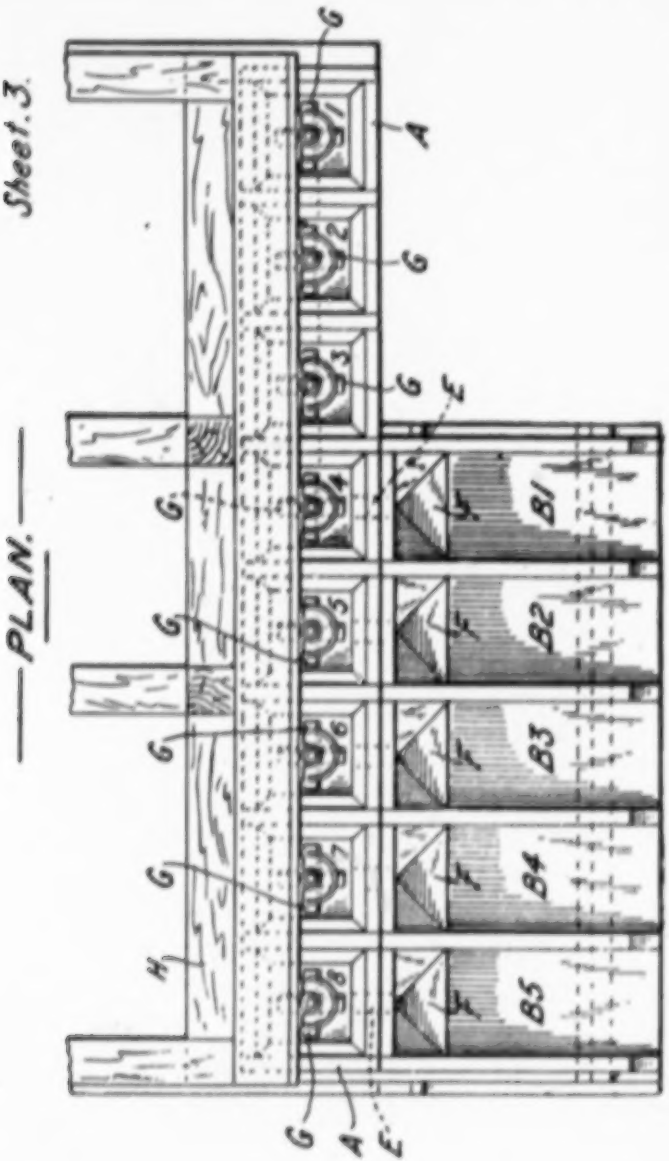
COMPLAINANTS' EXHIBIT, KING JOHN'S COURT STANDARD PLANT.



SIDE ELEVATION. Sheet 2.

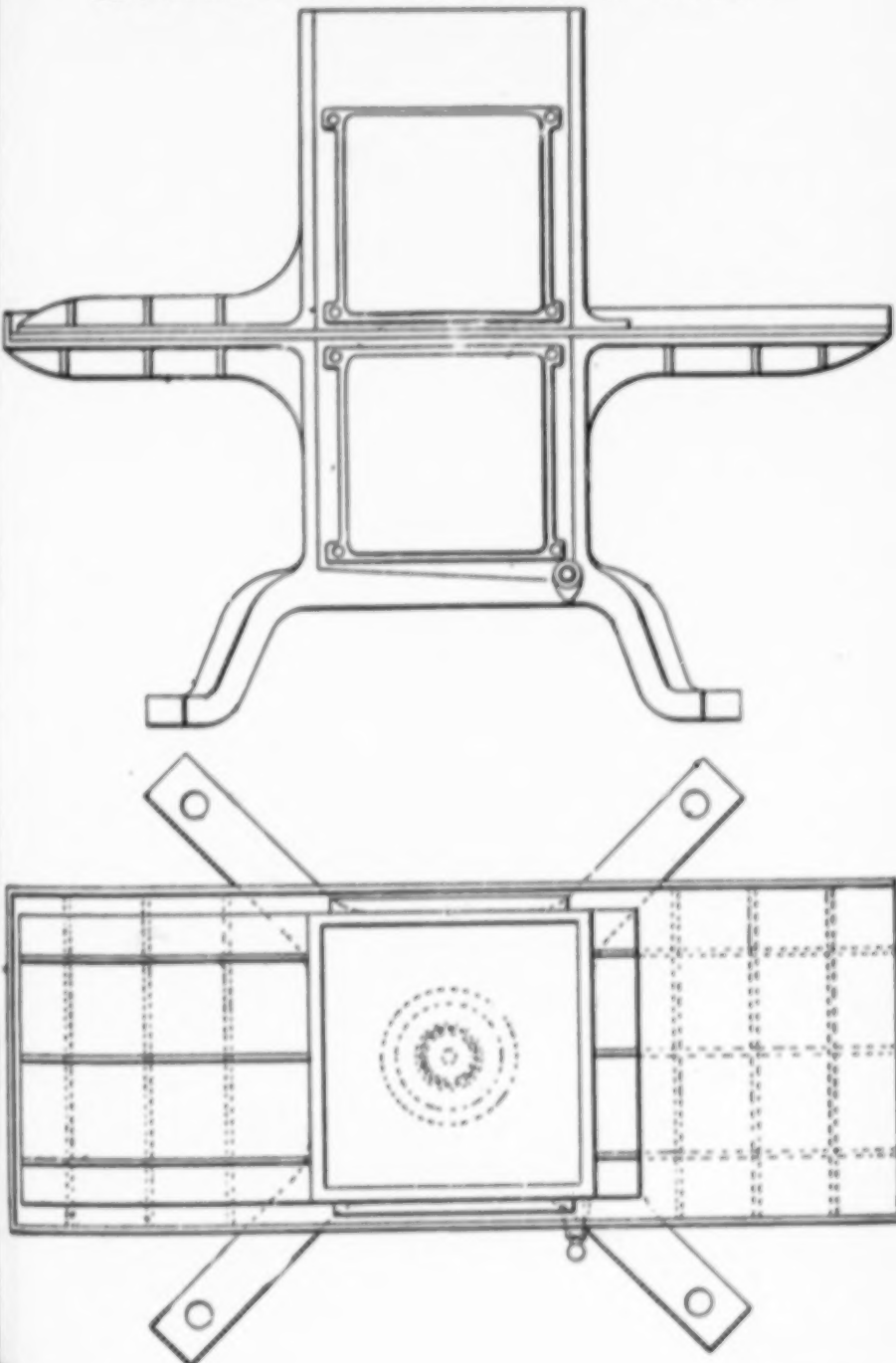
COMPLAINANTS' EXHIBIT, KING JOHN'S COURT STANDARD PLANT.

1308

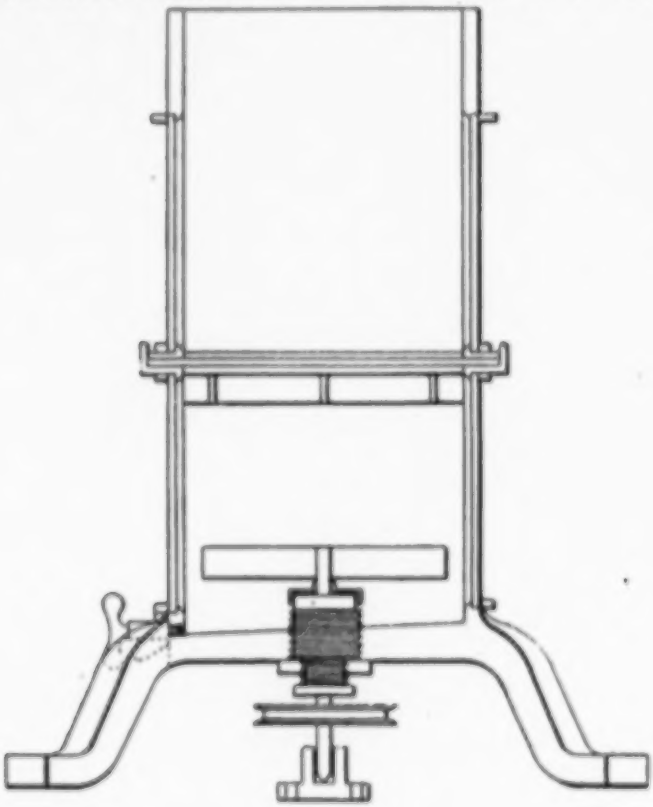


1310

COMPLAINANTS EXHIBIT FIRST TRACING SLIDE MACHINE

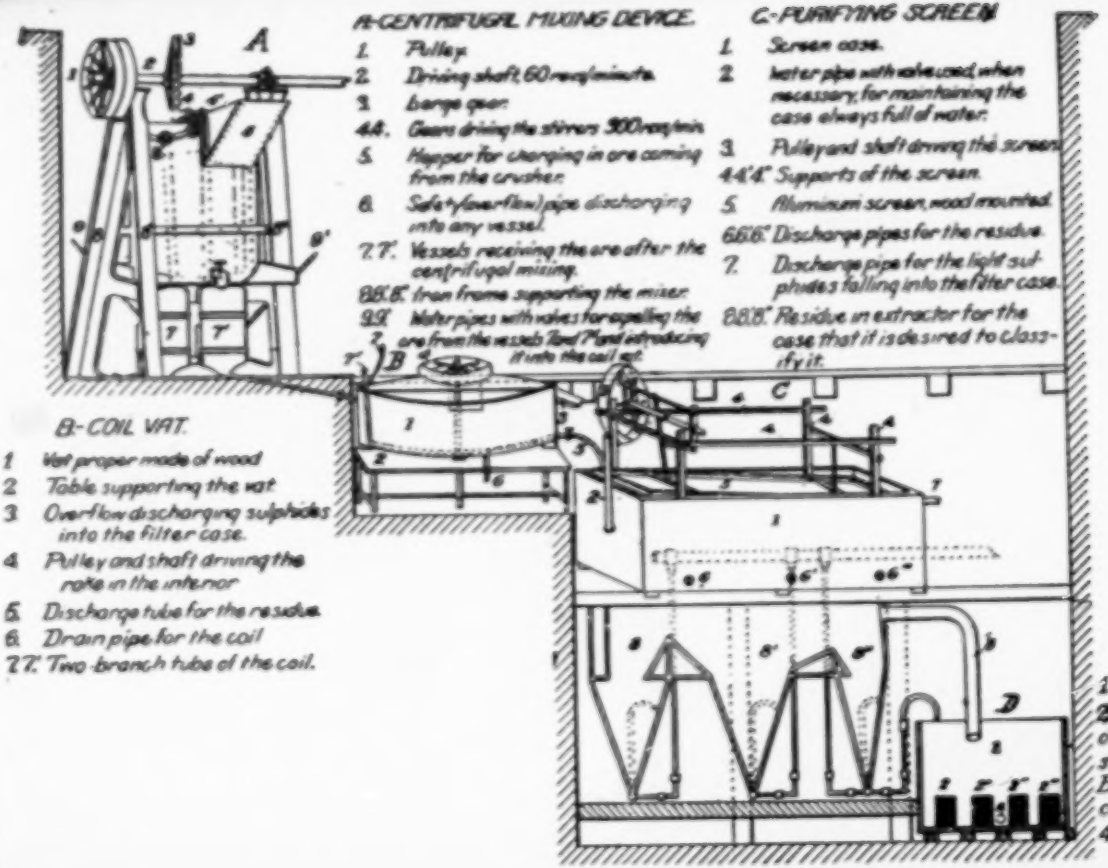


COMPLAINANTS EXHIBIT FIRST TRACING SLIDE MACHINE.



MINERALS SEPARATION LIMITED.
62 London Wall
Drawing No 100
Date .....

COMPLAINANT'S EXHIBIT FROMENT PLAN.



A-CENTRIFUGAL MIXING DEVICE.

1. Pulley.
2. Driving shaft, 60 revs/minute.
3. Barge gear.
4.4. Gears driving the stirrers 300 revs/min.
5. Hopper for charging in ore coming from the crusher.
6. Safety (overflow) pipe discharging into any vessel.
7.7. Vessels receiving the ore after the centrifugal mixing.
8.8.8. Iron frame supporting the mixer.
9.9. Water pipes with valves for expelling the ore from the vessels 7 and 7' and introducing it into the coil vat.

B-COIL VAT.

1. Vat proper made of wood
2. Table supporting the vat
3. Overflow discharging sulphides into the filter case.
4. Pulley and shaft driving the rake in the interior
5. Discharge tube for the residue.
6. Drain pipe for the coil
7.7. Two-branch tube of the coil.

C-PURIFYING SCREEN

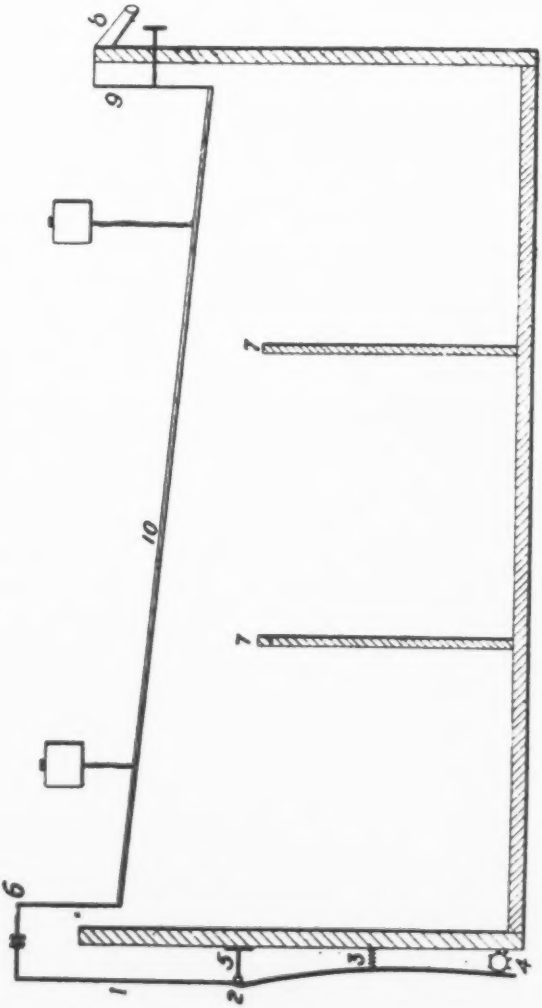
1. Screen case.
2. Water pipe with valve used when necessary, for maintaining the case always full of water.
3. Pulley and shaft driving the screen.
4.4.4. Supports of the screen.
5. Aluminium screen, wood mounted.
6.6.6. Discharge pipes for the residue.
7. Discharge pipe for the light sulphides falling into the filter case.
8.8.8. Residue in extractor for the case that it is desired to classify it.

D-FILTER CASE.

1. The case proper.
2.2.2. Canvas filters consisting of a wooden frame, with canvas stretched on both sides. Between the two canvases is contained charcoal powder.
4. Emergency discharge pipe.

COMPLAINANT'S EXHIBIT FROMENT DRAWING 17.

1313

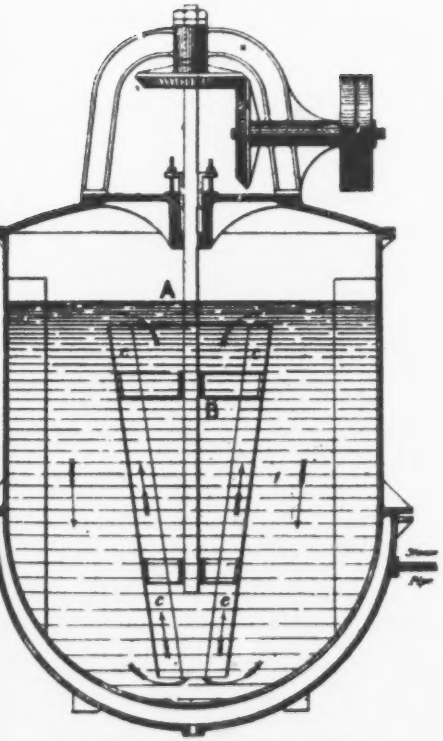


1. Iron Vibrator.
2. Spindle.
3. Spring.
4. Eccentric.
5. Iron bracket to be fixed to the vat.
6. Countershock mounted on the vat
7. Partitions.
8. Overflow.
9. Flexible iron stops
10. Screen.

COMPLAINANT'S EXHIBIT-YOUNG FIRST CIRCULAR

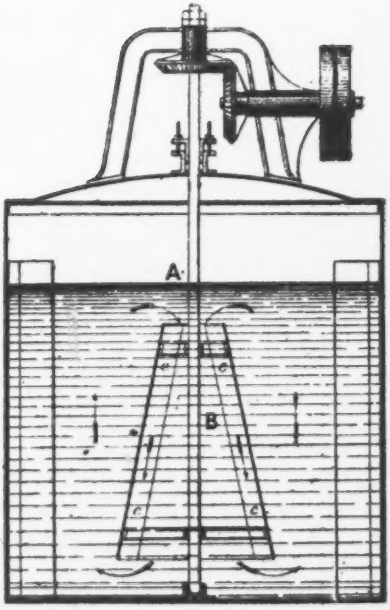
THE RAPID MIXER

Fig 1



Cast Iron Tank with Steam Jacket

Fig 2



Wrought Iron Tank Circular or Square

Burt, Boulton & Haywood & E R Gabbett's

——— Patent. ———

1315–16 COMPLAINANTS' EXHIBIT.

Young First Circular.

The Rapid Mixer is suitable for mixing any description of liquids or semi-liquids, irrespective of their difference in specific gravity.

The acting principle is centrifugal force which operates on that portion of the contents of the vessel **A** which is enclosed by the revolving cone **B**, and is thus caused to rotate with the cone by the vanes or vertical baffle plates *c c*.

The material to be treated is thus caused to mount the inside of the cone as shewn in Figure 1, it then flows out over the top, and returns again at the bottom, and the whole contents are thus circulated and turned over with a violent mixing action.

The rapidity of this circulation is governed by the speed at which the cone is driven, but a very moderate rate is sufficient for all practical purposes.

In Figure 2 the cone is inverted and the reverse action to that described above takes place, the contents being drawn from the top and discharged at the bottom, the most suitable form depending on the composition of the materials to be treated.

The advantages claimed for the Rapid Mixer are:—

1. The thorough and complete manner in which the mixing operation is carried out on materials differing very considerably in specific gravity; for example, if mercury and water are placed in the vessel as shewn in Figure 1, the former will be drawn up and distributed in a fine shower through the latter, although the difference in gravity in this case is as 1 to 13·59.

1316 2. Simplicity of form.

3. No working parts need be in contact with the materials to be used.

4. The cone can be made of any material, even stoneware or glass, being thus applicable to the most corrosive liquids.

5. It can be adapted to any existing tank either round or square, and the cones can be used singly or in series.

6. The very small amount of power required in working.

Note.—The Rapid Mixer can be made of any size, and the form varied to suit special requirements, it is applicable to all forms of manufacture, where the intimate admixture of liquids or semi-liquids is required.

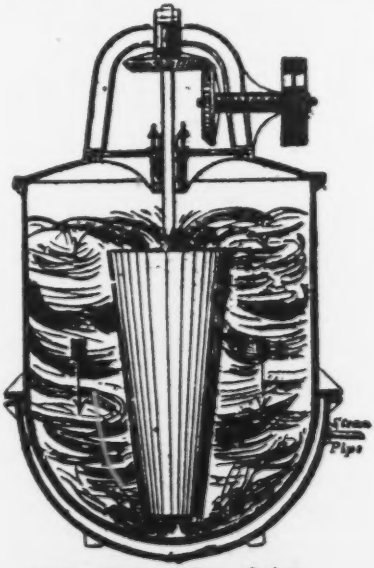
All information and estimates can be obtained from Messrs. H. Young & Co., Engineers, Eccleston Street, Pimlico, London, and the apparatus can be seen at work by appointment.

1318

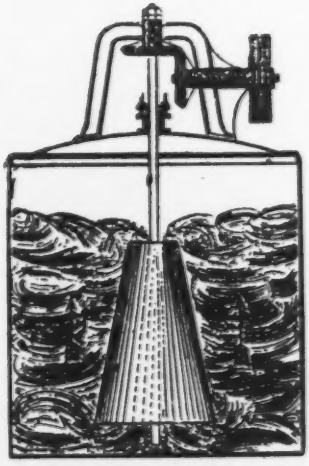
COMPLAINANT'S EXHIBIT-YOUNG ADVERTISEMENT "A"

THE RAPID MIXER.

BURT, BOULTON, & HAYWOOD and E. R. GABBETT'S PATENT.



Cast-Iron Tank with Steam Jacket



Wrought-Iron Tank, Circular or Square.

This Mixer is specially suited for all operations where the perfect Admixture of Liquids or Semi-Liquids is required, irrespective of their difference in Specific Gravity.

ADVANTAGES:—

In Action absolutely Perfect.
Simplicity in Construction, and easily adapted to any Tank.
No Working Parts need come in contact with Materials treated.
Wear and Tear practically Nil
Minimum Power in Driving.

Can be made in any Material, even Glass or Stoneware, and is therefore applicable to the most Corrosive Substances.

All Information and Estimates can be obtained from

MESSRS. H. YOUNG & CO., ECCLESTON IRONWORKS, PIMLICO, LONDON, S.W.

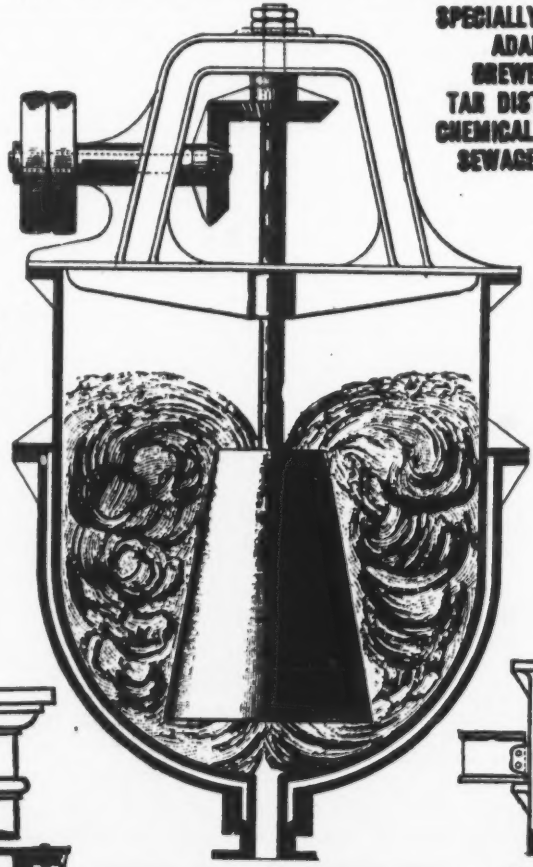
Engineers, Ironfounders, and Manufacturers of Machinery and Constructional Ironwork.

THE RAPID MIXER

BURT, BOULTON & HAYWOOD & E. R. GABBETT'S PATENT.

Telephone No. 3067.

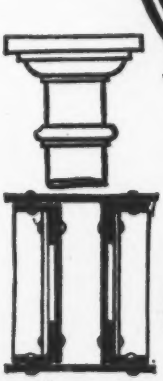
SPECIALLY ADAPTED FOR BREWERIES, TAR DISTILLERS, CHEMICAL AND SEWAGE WORKS.

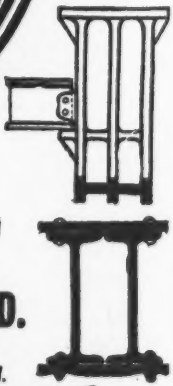


ROLLED JOISTS, ANGLES PLATES, and TEES, kept in stock.

RIVETTED GIRDERS and CASTINGS of every description made in London.

4783





STEEL AND WROUGHT-IRON CONSTRUCTIONAL WORK.

H. YOUNG & CO., LD.

ECCLESTON IRON WORKS, PIMLICO, and HAYLE FOUNDRY WHARF NINE ELMS, S.W.

Complainants' Exhibit Young Advertisement B.
United States District Court - District of Montana
Minerals Separation Limited and another
vs.
James M. Hyde
London September 3. 1912 J. Phillips Crawley Commissioner

1320 United States Circuit Court of Appeals for the Ninth Circuit.

No. 3081.

BUTTE AND SUPERIOR MINING COMPANY, Designated as Butte and Superior Copper Company, Limited, a Corporation, Appellant,

vs.

MINERALS SEPARATION, LIMITED, a Corporation; MINERALS SEPARATION AMERICAN SYNDICATE, LIMITED, a Corporation, and Minerals Separation North American, a Corporation, Appellees.

Substituted Pursuant to Order Filed March 19, 1918, for Incorrect Copy Filed November 10, 1917.

TRANSCRIPT OF RECORD.

Volume 4.

(Pages 1321 to 2196, Inclusive.)

Upon Appeal from the United States District Court for the District of Montana.

Filed Mar. 19, 1918. F. D. Monckton, Clerk.

1321 *Defendant's Record.*

1322–3 United States Circuit Court, District of Montana, Northern Division.

In Equity.

No. 1076.

MINERALS SEPARATION, LIMITED, and MINERALS SEPARATION AMERICAN SYNDICATE, LIMITED, Complainants,

vs.

JAMES M. HYDE, Defendant.

Answer.

The Answer of James M. Hyde, Defendant, to the Bill of Complaint of the Complainants, Minerals Separation, Limited, and Minerals Separation, American Syndicate, Limited.

This defendant, now and at all times saving and reserving unto itself all and all manner of benefit and advantage of exception which can or may be had or taken to the errors, uncertainties or other im-

perfections contained in the bill of complaint herein, for answer thereto, or so much or such parts thereof as it is advised it is material to make answer unto, says as follows:

I.

This defendant is not informed, save by the bill of com-
1324 plaint, that the complainants, or either of them, are corporations organized or existing under or by virtue of the laws of Great Britain, or of any other country, state or nation, or are inhabitants of Great Britain, or any other country, having their principal offices in London, England, or elsewhere, and therefore neither admits nor denies the same, but calls for strict proof thereof.

II.

This defendant admits that he is a resident of Basin, Jefferson County, State of Montana, and an inhabitant of the Northern Division of the District of Montana.

III.

This defendant, upon information and belief, denies that Henry Livingstone Sulman, Hugh Fitzalis Kirkpatrick-Picard, or John Ballot did invent or were the original, first or joint inventors of any new or useful improvements in Ore Concentration described in the letters patent referred to in said bill of complaint; denies that the alleged invention set forth in the patent sued upon was not known or used in the United States before the alleged invention thereof by the patentees, said Henry Livingstone Sulman, Hugh Fitzalis Kirkpatrick-Picard and John Ballot; denies that said alleged invention was not patented or described in any printed publication in any country before their alleged invention or discovery thereof or more than two years prior to their application for letters patent of the United
1325 States therefor; denies that said alleged invention was not in public use or on sale in the United States for more than two years prior to their said application for patent, and had not been patented in any country foreign to the United States on an application filed by them or their legal representatives or assigns more than twelve months prior to the filing of their said application for letters patent of the United States; and denies that said invention had not been abandoned to the public.

IV.

This defendant admits Henry Livingstone Sulman, Hugh Fitzalis Kirkpatrick-Picard, and John Ballot obtained letters patent of the United States No. 835,120, dated November 6, 1906, for alleged improvements in ore concentration; but this defendant denies that said patentees were the first or joint inventors or discoverers of said alleged improvements; and denies that the same involved any im-

provements in ore concentration; and denies that they made due or formal application to the Commissioner of Patents of the United States for letters patent of the United States therefor in accordance with the then existing laws of the United States; and denies that they duly complied in all respects with the conditions and requirements of said laws; and defendant is not informed, and has no knowledge, save by said bill of complaint, as to whether said letters patent No. 835,120 were signed by the Assistant Secretary of the Interior, and countersigned by the Commissioner of Patents and sealed
1326 with the seal of the Patent Office in due form of law, and therefore denies the same; and denies that said letters patent secured to said patentees, their executors, administrators and legal representatives for the term of seventeen years from the 6th day of November, 1906, or any period, the full, exclusive, or any right of making, using and selling the alleged improvements in ore concentration alleged to be shown, described and claimed in said letters patent, throughout the United States and the territories thereof; and this defendant is not informed, and has no knowledge, save by said bill of complaint, that said letters patent are now on record in the United States Patent Office, and calls for strict proof of the same.

V.

This defendant is not informed, and has no knowledge, save by said bill of complaint, that on or about the 7th day of December, 1909, or at any other time, the said Henry Livingstone Sulman, Hugh Fitzalis Kirkpatrick-Picard and John Ballot, by an instrument in writing, duly, or at all, executed or delivered by them and bearing date of the last-named day, or any date whatsoever, assigned and transferred to the complainant, Minerals Separation, Limited, all, or any, right, title or interest in or to the said letters patent and invention, or that the said instrument in writing was duly, or at all, recorded in the Patent Office of the United States on or about the 28th day of August, 1911, or at any other time, and there-
1327 fore denies the same.

VI.

This defendant is not informed, and has no knowledge, recollection or belief, save by said bill of complaint, that on or about the 10th day of October, 1910, or at any other time, said complainant, Minerals Separation, Limited, by an instrument in writing duly, or at all, executed, or delivered, or bearing date of the last-named day, or any date whatsoever, granted unto said complainant, Minerals Separation, American Syndicate, Limited, or that said Minerals Separation American Syndicate, Limited, received or accepted the sole, exclusive, or any, right, license, power or authority to apply, use or exercise in the United States of America the alleged invention described in said letters patent No. 835,120, for the term of two years, or any other time from the said 10th day of October, 1910, or from any other date, together with the option to purchase said letters patent during said

term of two years, or any other term, or at all, and therefore denies the same.

VII.

This defendant is not informed, and has no knowledge, recollection or belief, save by said bill of complaint, that the said complainants became or now are the sole owners of all, or any right, title or interest in or to the said letters patent or the said alleged inventions covered thereby, or any or all rights therein or thereunder
1328 within or throughout the United States, and therefore denies the same (and this defendant denies the same); and this defendant denies that the alleged rights or privileges alleged to be secured by the said letters patent have been generally, or at all, acquiesced in throughout the United States, or any part thereof, and denies that the said alleged invention described in said letters patent is of great, or any, value, or utility to the complainants herein or to the public generally, or at all, and this defendant denies that the complainants herein have made the said alleged invention profitable to themselves or to the public by careful, elaborate, or any, tests of said invention in its application to a wide, or any, variety of ores, or by extensive, or any, commercial use of the said alleged invention in different, or any, parts of the world, or by numerous, or any, demonstrations of the utility of said invention in the treatment of ores that are mined or treated in the United States, or elsewhere; and denies that the complainants have made, or that they are making, great, or any, efforts toward the introduction of said alleged invention into commercial, or any, use in the United States; and this defendant denies that the complainants have invested large sums of money, or any sums of money, in said alleged invention in the demonstration thereof or the efforts to introduce the same into use in the United States, or in making the same valuable to the public or to themselves; and this defendant denies that complainants will realize or receive large gains and profits, or any gains and profits, from the said
1329 alleged invention if this defendant shall be restrained from practicing said alleged invention.

VIII.

This defendant admits that he was for a period of about one year in the employ of the complainant, Minerals Separation, Limited, such employment having terminated on or about February 1, 1911, but this defendant denies that when thus employed he was instructed by the engineers or experts of the complainant in all or any of the technical details or particulars as to the said letters patent No. 835,120, or the installation or use of the process of ore concentration constituting said alleged invention; and avers that while in the employ of said complainant, Minerals Separation, Limited, as aforesaid, he was instructed in the practice and operation of certain processes which had been invented and discovered long prior to the alleged invention by said patentees of the process set forth in their said pat-

ent, and further avers that while he was in the employ of said complainant, Minerals Separation, Limited, he had no knowledge of said United States letters patent No. 835,120, was not instructed regarding the application or use of the process set forth in said patent, never saw said process in operation, and received no information, knowledge, or instruction from said complainant, Minerals Separation, Limited, other than information, knowledge and instruction regarding matters known to the public long prior to the said alleged invention of said Henry Livingstone Sulman, Hugh Fitzalis Kirkpatrick-Picard, and John Ballot, or their application of let-
1330 ters patent of the United States therefor.

IX.

This defendant denies that well knowing, or knowing at all, the alleged rights secured to said complainants, or contriving to injure said complainants or to deprive them of the benefits or advantages from said alleged invention and letters patent, he did after the issuance of said letters patent, or at any other time, in violation of any of the rights of said complainants or in infringement of said letters patent No. 835,120, or in defiance of any rights of said complainants at the town of Basin, in the County of Jefferson, State of Montana, or elsewhere, install any apparatus for or carry on the use of the process of ore concentration set forth and claimed in the aforesaid letters patent No. 835,120, and denies that he confederated with others, or confederated at all, in such installation or use, or is threatening to further induce others to make such installation or use in infringement of complainants' alleged rights under the said letters patent; and this defendant denies that said complainants have been, or still are, deprived of great gains and profits, or of any gains and profits, that they might or would have otherwise obtained, and further denies that such alleged profits of which complainants have been deprived have been realized or enjoyed by this defendant by or through unlawful acts or doings; and this defendant admits that he has installed an apparatus and operated a process at the town
1331 of Basin, Montana, for the concentration of ores, but avers that said apparatus and process consist in the use of certain principles and machines which were invented and discovered long prior to the said alleged invention of said patentees, and further consists in certain apparatus and operations invented and discovered by this defendant, and further avers that the process practiced by him in the said town of Basin, Montana, does not infringe said letters patent, does not utilize any information conveyed by said letters patent, and consists solely in the application of principles which were either discovered by said defendant or were the property of the public in the United States.

X.

This defendant denies that he has made and received, or is making and receiving, large, or any, profits, or advantages from the infringement of the said letters patent.

XI.

And this defendant denies that he has installed or used the said alleged invention set forth in said letters patent, or that he has committed any other unlawful act in this regard in defiance of the rights of the complainants, and further denies that he has committed any acts whatever which have had the effect of aiding, encouraging or inducing others to infringe said letters patent in disregard of the complainants' rights.

1332

XII.

This defendant denies that the complainants have caused any notice to be given to him of the alleged infringement of the alleged rights of complainants in the premises, or that the complainants have requested him to desist or refrain therefrom, and this defendant denies that he has disregarded any such notices, or that he has refused to desist from infringement of said letters patent or has continued such infringement after such notice of complainants' alleged rights, or at any time.

XIII.

This defendant further says that said Henry Livingstone Sulman, Hugh Fitzalis Kirkpatrick-Picard, and John Ballot were not the original first or true inventors of the alleged invention in ore concentration, which said letters patent No. 835,120 purport to embrace, or of any material or substantial part thereof; but that, on the contrary, said alleged invention, and all material and substantial parts had before their alleged invention been fully and clearly described or claimed in the following mentioned letters patent:

1333

Letters Patent of the United States.

348,157.	August 24, 1886	C. J. Everson
466,753.	January 5, 1892	E. A. Hockley
469,599.	February 23, 1892	A. M. Rouse
653,340.	July 10, 1900	F. E. Elmore
676,679.	June 18, 1901	F. E. Elmore
689,070.	December 17, 1901	A. S. Elmore
692,643.	February 4, 1902	A. S. Elmore
735,071.	August 4, 1903	G. D. Delprat
736,381.	August 18, 1903	M. F. R. Glogner
745,960.	December 1, 1903	I. F. Good
768,035.	August 23, 1904	G. D. Delprat
771,075.	September 27, 1904	C. Kendall
776,145.	November 29, 1904	C. V. Potter

Letters Patent of Great Britain.

488. February 23, 1860.....W. Haynes
12,778. June 5, 1902.....Lake (Froment)

Also patented or described and contained in other letters patent, the dates, numbers and grantees of which this defendant is not now able to specify, but prays to be allowed hereafter to add by amendment of this answer or otherwise, if it shall become necessary.

Also illustrated and described in printed publications, the names and dates of which defendant is not able to specify, but prays to be allowed hereafter to add to this answer by amendment or otherwise, if it shall become necessary.

1334

XIV.

This defendant avers that for the purpose of deceiving the public the description and specifications filed by the said patentees in the Patent Office were made to contain more than the whole truth relative to their alleged invention or discovery, and more than is necessary to produce the desired effect.

XV.

This defendant avers that the said patentees were not the original and first inventors or discoverers of any material and substantial part of the thing patented, but that, on the contrary, the process which their said patent purports to embrace was known and used by Edmund B. Kirby, of Rossland, British Columbia, Canada, long prior to the alleged invention and discovery thereof by said patentees, and that said Edmund B. Kirby introduced knowledge of said process into the United States in the month of December, 1903, by filing applications in the United States Patent Office for patents, upon which applications letters patent Nos. 809,959 and 838,626 were granted on January 16, 1906, and December 18, 1906, respectively.

XVI.

This defendant says that the said patentees, Henry Livingstone Sulman, Hugh Fitzalis Kirkpatrick-Picard and John Ballot have admitted that the alleged invention which said letters patent
1335 No. 835,120 purport to embrace, and each and every material and substantial part thereof was old and known to others prior to their alleged invention and discovery thereof, and that said patentees made said admissions in the following described letters patent:

Letters Patent of the United States.

793,808, Sulman & Kirkpatrick-Picard, application filed October 5, 1903, patented July 4, 1905.
835,479, Sulman, Kirkpatrick-Picard & Ballot, application filed May 29, 1905, patented November 6, 1906.
879,985, Sulman, Kirkpatrick-Picard & Ballot, application filed February 20, 1905, patented February 25, 1908.

Letters Patent of Great Britain.

17,109, August 6, 1903, Cattermole, Sulman & Kirkpatrick-Picard.
20,419, September 22, 1903, Sulman & Kirkpatrick-Picard.
5,260, March 13, 1905, Sulman, Kirkpatrick-Picard & Ballot.
19,709, September 29, 1905, Sulman.
26,712, December 21, 1905, Sulman, Kirkpatrick-Picard & Ballot.

XVII.

Defendant, further answering, says that the complainants herein are not entitled to the relief prayed for in their bill of com-
1336 plaint, without this that there is any other matter, cause or thing in the said bill of complaint contained, material or necessary for this defendant to make answer unto, and not hereinbefore sufficiently answered, confessed or avoided, traversed, or denied, is true; all of which this defendant is ready to aver, maintain and prove as this Honorable Court shall direct, and prays to be hence dismissed with his costs in this behalf most wrongfully sustained.

KREMER, SANDERS & KREMER,
Solicitors for Defendant.

SHERIDAN, WILKINSON, SCOTT & RICHMOND, *Of Counsel.*

1337 *Amendment to Answer.*

United States District Court, District of Montana.

In Equity.

No. 1076.

MINERALS SEPARATION, LIMITED, and MINERALS SEPARATION AMERICAN SYNDICATE, LIMITED, Complainants,

vs.

JAMES M. HYDE, Defendant.

Now comes the defendant, James M. Hyde, and amends his answer in the above-entitled suit in the following manner, to-wit:

By canceling that part of his answer following the numeral XIII and extending from and including the twenty-third line of page 9 of said answer through and including the twenty-second line of page 10 [in the printed copy of the testimony the canceled matter extends from the numeral XIII, page —, through and including the lists of patents on page —], and substituting therefor the following:

"This defendant further says that said Henry Livingstone Sulman, Hugh Fitzalis Kirkpatrick-Picard and John Ballot were not the original first or true inventors of the alleged invention in ore concentration which said letters patent No. 835,120 purport to embrace, or of any material or substantial part thereof, but that, on the contrary, said alleged invention and all material and sub-
1338 stantial parts thereof had before their alleged invention been fully and clearly described or claimed in the following mentioned letters patent:

Letters Patent of the United States.

345,951.	July 20, 1886	H. Bradford
348,157.	August 24, 1886	C. J. Everson
466,753.	January 5, 1892	E. A. Hockley
469,599.	February 23, 1892	A. M. Rouse
471,174.	March 22, 1892	C. B. Hebron and C. J. Everson
653,340.	July 10, 1900	F. E. Elmore
676,679.	June 18, 1901	F. E. Elmore
689,070.	December 17, 1901	A. S. Elmore
692,643.	February 4, 1902	A. S. Elmore
729,805.	June 2, 1903	J. and L. Stoveken
735,071.	August 4, 1903	G. D. Delprat
736,381.	August 18, 1903	M. F. R. Glogner
745,960.	December 1, 1903	I. F. Good
768,035.	August 23, 1904	G. D. Delprat
771,075.	September 27, 1904	C. Kendall
776,145.	November 29, 1904	C. V. Potter
777,273.	December 13, 1904	A. E. Cattermole
777,274.	December 13, 1904	A. E. Cattermole, H. L. Sulman and H. F. Kirkpatrick-Picard
788,247.	April 25, 1905	A. E. Cattermole, H. L. Sulman and H. F. Kirkpatrick-Picard

1339

793,808.	July 4, 1905	Sulman and H. F. Kirkpatrick-Picard
809,959.	January 16, 1906	E. B. Kirby

Letters Patent of Great Britain.

488. February 23, 1860.....W. Haynes
12,778. June 4, 1902.....Lake (Froment)

Also that prior to the supposed invention or discovery of the alleged process patented in said letters patent No. 835,120 by said Henry Livingstone Sulman, Hugh Fitzalis Kirkpatrick-Picard and John Ballot each and every material and substantial part of said supposed invention or discovery so patented had been invented and used by and was known to the following named persons, and was fully described in applications for letters patent of the United States deposited and filed by said persons in the United States Patent Office prior to the supposed invention or discovery of said alleged process set forth in said letters patent No. 835,120 by said Sulman, Kirkpatrick-Picard and Ballot; that said applications were so deposited and filed in the United States Patent Office and that the letters patent of the United States were granted upon said applications as set forth below:

Moritz F. R. Glogner, a resident of Freiburg, in the Kingdom of Prussia, German Empire, on January 27, 1903, deposited and filed in the United States Patent Office his application for letters patent of the United States, and that letters patent No. 736,381 were
1310 granted thereon upon August 18, 1903.

Israel F. Good, a resident of Allentown, Pennsylvania, on October 1, 1902, deposited and filed in the United States Patent Office his application for letters patent of the United States, and that letters patent No. 745,960 were granted thereon upon December 1, 1903.

Guillaume D. Delprat, a resident of Broken Hill, Australia, on January 2, 1903, deposited and filed in the United States Patent Office his application for letters patent of the United States, and that letters patent No. 768,035 were granted thereon upon August 23, 1904.

Cosmo Kendall, a resident of Upper Norwood, Surrey, England, on July 21, 1903, deposited and filed in the United States Patent Office his application for letters patent of the United States, and that letters patent No. 771,075 were granted thereon upon September 27, 1904.

Charles V. Potter, a resident of Balaclava, Victoria, Australia, on January 14, 1902, deposited and filed in the United States Patent Office his application for letters patent of the United States, and that letters patent No. 776,145 were granted thereon upon November 29, 1904.

Arthur E. Cattermole, a resident of Highgate, London, England, on September 28, 1903, deposited and filed in the United States Patent Office his application for letters patent of the United States, and that letters patent No. 777,273 were granted thereon upon December 13, 1904.

1341 Arthur E. Cattermole, Henry L. Sulman and Hugh F. Kirkpatrick-Picard, all residents of London, England, on March 29, 1904, deposited and filed in the United States Patent Office their application for letters patent of the United States, and that letters patent No. 777,274 were granted thereon upon December 13, 1904. Arthur E. Cattermole, Henry L. Sulman and Hugh F. Kirkpatrick-Picard, all residents of London, England, on March 29, 1904, deposited and filed in the United States Patent Office their application for letters patent of the United States, and that letters patent No. 788,247 were granted thereon upon April 25, 1905.

Henry L. Sulman and Hugh F. Kirkpatrick-Picard, residents of London, England, on October 5, 1903, deposited and filed in the United States Patent Office their application for letters patent of the United States, and that letters patent No. 793,808 were granted thereon upon July 4, 1905.

Alfred Schwarz, a resident of New York City, New York, on April 19, 1905, deposited and filed in the United States Patent Office his application for letters patent of the United States, and that letters patent No. 807,501 were granted thereon upon December 19, 1905.

Alfred Schwarz, a resident of New York City, New York, on May 27, 1904, deposited and filed in the United States Patent Office his application for letters patent of the United States, and that letters patent No. 807,503 were granted thereon upon December 19, 1905.

Edmund B. Kirby, a resident of Rossland, Canada, on December 14, 1903, deposited and filed in the United States Patent Office his application for letters patent of the United States, and that letters patent No. 809,959 were granted thereon upon January 16, 1906.

Edmund B. Kirby, a resident of Rossland, Canada, on December 17, 1903, deposited and filed in the United States Patent
1342 Office his application for letters patent of the United States, and that letters patent No. 838,626 were granted thereon upon December 18, 1906.

By canceling that part of the answer following the numeral XVI and extending from and including the twenty-ninth line of page 11 of said answer through and including the twenty-second line of the twelfth page thereof [in the printed copy of the testimony the canceled matter extends from the numeral XVI, page 11, to the numeral XVII, page 12], and substituting therefor the following:

This defendant says that the said patentees, Henry Livingstone Sulman, Hugh Fitzalis Kirkpatrick-Picard and John Ballot have admitted that the alleged invention which said letters patent No. 835,120 purport to embrace and each and every material and substantial part thereof was old and known to others prior to their alleged invention and discovery thereof, and have stated that said alleged invention was the invention of others, and that said patentees made said admissions and statements in the following described letters patent, and in the applications therefor and proceedings in the United States Patent Office relating thereto:

Letters Patent of the United States.

793,808, Sulman & Kirkpatrick-Picard, application filed October 5, 1903, patented July 4, 1905.
835,143, Henry L. Sulman, application filed October 20, 1905, patented November 6, 1906.
835,479, Sulman, Kirkpatrick-Picard & Ballot, application filed May 29, 1905, patented November 6, 1906.
1343
879,985, Sulman, Kirkpatrick-Picard & Ballot, application filed February 20, 1905, patented February 25, 1908.

Letters Patent of Great Britain.

17,109, August 6, 1903, Cattermole, Sulman & Kirkpatrick-Picard.
20,419, September 22, 1903, Sulman & Kirkpatrick-Picard.
5,260, March 13, 1905, Sulman, Kirkpatrick-Picard & Ballot.
19,709, September 19, 1905, Sulman.
26,712, December 21, 1905, Sulman, Kirkpatrick-Picard & Ballot.

KREMER, SANDERS & KREMER,
Solicitors for Defendant.

It is stipulated that the foregoing amendment to the answer of defendant may be entered, provided, however, that should defendant prevail upon any of the matters set up in said amendment and not set up in his original answer, he may not recover costs for any proceedings prior to the deposition of the witness Eugene A. Byrnes.

McCONNELL & McCONNELL,
Solicitors for Complainant.
HENRY D. WILLIAMS,
Of Counsel.
KREMER, SANDERS & KREMER,
Solicitors for Defendant.

1344 *Deposition of Jesse C. Gibson.*

United States District Court, District of Montana.

In Equity.

No. 1076.

MINERALS SEPARATION, LIMITED, and MINERALS SEPARATION AMERICAN SYNDICATE, LIMITED, Complainants,

vs.

JAMES M. HYDE, Defendant.

The Deposition of Jesse C. Gibson, a witness in behalf of defendant in the above-entitled suit, taken by agreement of counsel before Charles H. Little, a Notary Public in and for the State of Montana, acting by consent of counsel for both parties as Special Examiner under the 67th Rule in Equity as amended, at the office of Kremer, Sanders & Kremer, State Savings Bank Building, Butte, Montana, beginning on Monday, April 1st, 1912, at 10 o'clock in the forenoon.

Appearances:

Henry D. Williams, Esq., for complainants;
J. Bruce Kremer, Esq., for defendant.

JESSE C. GIBSON, a witness produced in behalf of defendant, having been duly cautioned and sworn, testified as follows:

Direct examination.

By Mr. Kremer:

Q. 1. Please state your name, age, residence and occupation.

A. Jesse C. Gibson; 25 years of age; residence, Butte, Mon-
1345 tana; occupation, storekeeper for the Butte & Superior Copper Company.

Q. 2. What occupation did you follow immediately previous to your becoming storekeeper at the Butte & Superior?

A. Millman.

Q. 3. Were you employed on a flotation plant operated for the purpose of treating ore at Basin, Montana; if so, in what capacity?

A. I was, as an operator.

Q. 4. What were your duties in that connection?

A. To operate the machine.

Q. 5. By whom were you employed?

A. Butte Superior Copper Company.

Q. 6. Under whose direction were you working?

A. Mr. Hyde, the defendant.

Q. 7. State what was used in connection with the operation of the flotation plant.

A. Oil, acid and heat; that was all.

Q. 8. Did you have charge of the operation of the flotation plant?

A. I did on one shift of eight hours per day.

Q. 9. How long were you employed as such operator, and between what dates?

A. It was the latter part of July, 1911, up until about February 7th, 1912.

Q. 10. Did you know anything about the so-called flotation process wherein oil and acids are used, before starting to work upon the plant at Basin?

A. I did not.

1346 Q. 11. What were your instructions as to the regulation of the supply of oils and acids in the process and by whom were they given?

A. I was instructed to use oil and acid to produce the best results. I was instructed by Mr. Hyde.

Q. 12. What were you told was the indication of too much oil and acid?

A. Too much oil was indicated by a flat film on the surface of the water, the mineral forming globules and sinking. Too much acid, the mineral would not float. Too little oil, there was no separation of the minerals and waste. Too little acid, made a lower grade concentrate.

Q. 13. What, if anything, were you told as to the actual quantity of oil and acid you were to use in operating the plant for Mr. Hyde, and by whom were you instructed?

A. The amounts were left entirely to our own judgment, and to use the amount that would produce the best results. That was Mr. Hyde's instructions.

Q. 14. What kind of oil and what kind of acid was used?

A. Oleic oil and sulphuric acid.

Q. 15. In operating the plant, did you weigh or measure the quantity of oil or acid with a view to using any proportion relative to the amount of ore?

A. No.

By Mr. Williams: The objection is here noted to the testimony as so far developed, that the witness is describing the operation
1347 of certain physical apparatus which are not produced nor competently proved, and to which the complainants and their representatives have not been granted access for examination. The general objection is therefore made that the testimony is secondary and incompetent, although this objection will be withdrawn if opportunity is given to complainants' counsel and expert to examine the apparatus as to the operation of which the witness is testifying.

Q. 16. When you were operating the flotation plant wherein the flotation process was used, did you have any knowledge of the amount of acid and oil by weight or measure that you were using, or the proportion of same to the amount of ore being treated?

A. I did not.

Q. 17. By what were you guided in the operation of this process?

A. By results obtained.

Q. 18. What would be the course of your procedure in order to obtain the best results?

A. If to my judgment more oil was needed, it was added; if less, I reduced the amount. The same with acid.

Q. 19. How often would you find it necessary to vary the oil and acid supplied in order to obtain the best results that you speak of?

By Mr. Williams: The general objection stated after the
1348 answer to Q. 15 is now repeated as to this question for the obvious reason that no intelligent presentation of the alleged facts as to which the witness has testified can be made, and no intelligent understanding had thereof, in the absence of a complete comprehension of the physical apparatus as to the operation of which the witness is testifying. It is stipulated that this objection may be continued without repetition to all further questions on this line.

By Mr. Kremer: For the purpose of clearness I temporarily withdraw Q. 19.

Q. 20. Describe the flotation plant upon which you operated at Basin, at the time of Mr. Nutter's visit, this being the plant known as the experimental plant.

By Mr. Williams: Objection is made to the description of physical apparatus not produced or submitted to the inspection of opposing parties, as secondary and incompetent.

A. The plant consisted of a series of agitating boxes and spitzkasten. There were six agitating boxes and three spitzkasten on the first machine; my mind is not clear as to the number of boxes on the cleaner machine. The pulp entered the first agitator box; from there flowed to the second; from the second to the third, where it flowed into the first spitzkasten. The tailings from the first spitzkasten went to the first agitator box of the second cell; from there it flowed to the second agitating box; from there to the second spitzkasten. The tailings from the second spitzkasten went
1349 to the third cell, where there was but one agitator box. The tailings from that went to the tailings dump. The concentrates from the three spitzkasten I have just described went to the first agitator box on the cleaner, where they were agitated and flowed into the first spitzkasten on the cleaner. The concentrate made there went to the concentrate bin. The tailings from the first spitzkasten went to the agitator boxes on the second cell of the cleaner, where they agitated and flowed onto the second spitzkasten. The concentrate made on that spitzkasten went to the concentrate bin; the tailings were returned to the second cell of the rougher to be retreated. By the rougher I mean the first three spitzkasten described.

The acid was fed to the pulp in a launder approximately 100 feet from the plant, previous to entering the settling tanks. The oil was added in the first agitator box in the first spitzkasten.

The agitators were a propeller-like blade mounted on vertical shafts, driven by a belt.

Q. 21. What do you mean by the term "cell" that you use in your description?

By Mr. Williams: The same objection.

A. One agitator box and its spitzkasten complete make a cell, or one spitzkasten and its agitator box or boxes make a cell. These are commonly referred to as units.

Q. 22. How often would you find it necessary to vary the oil and acid supplied in operating the process, in order to obtain the best results that you speak of?

1350 A. That was governed by conditions. The change being made as often as needed to produce the best results. It varied greatly, as often as every four or five minutes, and sometimes we wouldn't have to change for half an hour.

Q. 23. Where was the heat, if any, applied in the operation of the plant?

A. In two places, in the oil tank which supplies the oil to the machine, and in the first agitator box of the first unit.

Q. 24. You stated that the oil was added in the first agitator box in the first spitzkasten. Was it added in the agitator box or the spitzkasten?

A. In the agitator box.

Q. 25. What was the condition of the oil that you received for use in the flotation plant; I mean the physical condition?

A. A solid mass.

Q. 26. You refer to heat being used in the plant. What is your judgment as to why this heat was applied?

By Mr. Williams: Objected to as incompetent, in that it calls for an expression of opinion by a witness who has expressly disclaimed any theoretical knowledge of the subject of which he is testifying.

By Mr. Kremer: Conceding that counsel is correct in that the witness is not testifying as an expert upon the theories of the so-called process, I withdraw the question.

1351 Q. 27. State what you mean by obtaining the best results in the operation of the so-called flotation process.

A. High grade concentrates and clean tailings.

Q. 28. Do you know Mr. Edward H. Nutter?

A. Not personally acquainted with him; I might know him if I should see him again.

Q. 29. Well, where did you ever see him?

A. In Basin, Montana. On the night of August 10th, 1911, in the experimental plant of the Butte Superior Copper Company.

Q. 30. Detail what occurred between you that evening, and relate the conversation had between you.

A. It was between 11 and 12 o'clock P. M., August 10th, 1911, when Mr. Nutter came into the experimental plant which I was in charge of at that time. My back being turned to the door, he was in the plant before I saw him, and was coming up the steps that

led to the platform around the machine. I jumped down from the stand where I was and informed him that we allowed no visitors in the plant and asked him to get out,—told him to get out. He said that that was all right, and wanted to know what I was doing there. I told him that it was none of his business, and again asked him to get out. He then asked me what caused the mineral to float, and also asked me for a sample of the concentrates. I again told him that it was none of his business, whereupon he took a handful of the concentrates and started out of the door. I followed him,
1352 stopped him, and asked him what his business was, and told him that if he had any business around there to go with me and see Mr. Hyde, who lived within a short distance of the plant. He said that he did not care to see Mr. Hyde, but I insisted that he go with me to Mr. Hyde, as I was in charge of the plant, and was instructed to allow no visitors to enter the plant, and might possibly lose my situation for so doing. He told me that I need not worry about losing my situation, that if I would leave my name and address with him he would look out for that. I asked him what kind of a man he thought I was, and that if he was a man he would go with me and see Mr. Hyde. He refused to do so, and went, presumably, to his hotel. I went over to the house, awakened Mr. Hyde and informed him of what had happened.

Q. 31. Was or was not the plant at the time of the visit of Mr. Nutter operating under normal conditions as to the character of feed?

A. It was not.

Q. 32. State why?

A. The mill was down at that time, and we were treating the concentrates made on the vanners, feeding it into the flotation machine by buckets. The vanners were machines in the mill which treated the slimes, the concentrates being wheeled out and piled near the door of the experimental plant.

Q. 33. As I understand you, at the time of Mr. Nutter's visit you were feeding vanner concentrates into the machine directly, instead of the flowing pulp as it ordinarily came from the mill; is that correct?

1353 A. Yes, sir, that is the idea; that is what we were doing.

Q. 34. As a millman, are you familiar with the general grade of concentrates produced by that machine under ordinary working conditions?

A. Yes.

Q. 35. What would you say as to whether the concentrates procured by Mr. Nutter at the time referred to in your answer to Q. 30 was or was not an average grade of concentrate from that machine?

A. It was not.

Q. 36. Was it a higher or lower grade?

A. Well, I could not say at this time; I don't remember what the concentrate run at that time.

Q. 37. From your experience with this machine, would you say that the sample procured by Mr. Nutter in the manner that it was

procured, was a representative sample of the concentrate produced by that machine, even at that time?

A. It was not.

Direct examination closed.

Cross examination by Mr. Williams, de bene esse, without waiving the objections heretofore stated to the testimony of this witness, which are here repeated, that descriptions of the construction and operation of a physical apparatus which is not produced and not offered to the inspection of opposing parties are secondary and incompetent:

1354 X Q. 38. You have mentioned an oil tank, and you have said that the oil was fed to the flotation plant. In what manner was the oil conducted from the oil tank to the agitation box at which is entered the pulp?

A. By means of a short pipe and a valve for regulating the supply.

X Q. 39. Was the oil fed by gravity?

A. Yes.

X Q. 40. How was the oil warmed in the oil tank?

A. By a steam coil in the oil tank.

X Q. 41. What was the capacity of the oil tank?

A. I couldn't say as to the actual capacity; I judge about twenty gallons.

X Q. 42. In how many shifts of attendance was the plant operated each day?

A. Three.

X Q. 43. And was your shift eight hours?

A. Eight hours.

X Q. 44. You had to refill the oil tank now and then, did you not?

A. My helper did.

X Q. 45. About how often did that happen during your shift?

A. It all depended on conditions as to the amount of oil used.

X Q. 46. Well, as a general average, how often would it have to be refilled during the eight hours when it was in your charge?

A. I couldn't say.

X Q. 47. Did you ever refill it twice during your shift?

1355 A. Yes, I have refilled it twice, and more and less.

X Q. 48. How were the concentrates handled after they came out of the flotation plant?

A. Pumped to the concentrate bins.

X Q. 49. How many of these concentrate bins were there?

A. I think there were two.

X Q. 50. On an average, how many times did you fill a concentrate bin during your shift?

A. I don't know.

X Q. 51. Were the concentrate bins under your charge?

A. No, sir, they were not.

X Q. 52. Did they overflow one into the other, or did some one

have to make some change in the feed when one concentrate bin was full?

A. That was attended to by one of the men in the mill.

X Q. 53. How were the tailings handled?

A. They were carried away with the mill tailings.

X Q. 54. What became of them ultimately?

A. They flowed into the settling ponds first, and from there into the Boulder River.

X Q. 55. Was any of the water used over again?

A. No.

X Q. 56. You have said that the acid was fed to the pulp approximately 100 feet from the flotation plant, previous to entering the settling tank. Did you have charge of the regulation of the acid supply?

A. I did.

1355 X Q. 57. From what was this acid fed into the pulp?

A. From a small iron pot or kettle, through a pipe with a valve.

X Q. 58. What was the condition of this acid, dilute or concentrated?

A. What you might term crude sulphuric acid.

X Q. 59. What was the material or metal used in the acid feed pipe and valve?

A. Iron.

X Q. 60. What was the capacity of the iron pot or kettle from which the sulphuric acid was fed?

A. About three gallons.

X Q. 61. Was any of the water into which this sulphuric acid was fed wasted or flowed off before the pulp entered the flotation plant?

A. Yes.

X Q. 62. What you have called a settling tank, into which the acid was fed, is what is commonly known as a dewaterer, isn't it?

A. Yes.

X Q. 63. Do you know about what proportion of the water was flowed off or separated in the dewaterer?

A. I do not.

X Q. 64. Do you know what was the proprotion of water to ore in the pulp that entered the flotation plant?

A. I do not.

X Q. 65. Was the dewaterer under your charge?

A. Yes, it was.

1357 X Q. 66. Did you have to adjust it at any time?

A. There was a man stationed to do that under my directions.

X Q. 67. Before the pulp entered the dewaterer, what had been done to the ore and water of which it was composed?

A. The ore had been treated over jigs and tables, where it had been separated, and the slimes sent to the dewaterer and settled.

X Q. 68. From what part of the dewaterer did the pulp flow to the flotation plant?

A. From the bottom of the dewaterer.

X Q 69. Now as to this iron pot or kettle from which the sulphuric acid was fed, on the average, about how often was this refilled during your shift?

A. As often as necessary.

X Q. 70. And about how often was that, on the average?

A. It varied according to conditions.

X Q. 71. Did you ever refill it twice during your shift?

A. I refilled it twice, and less and oftener.

X Q. 72. You have said that when Mr. Edward H. Nutter inspected this flotation plant, you were treating the concentrates made on the vanners. How do these concentrates differ from the ordinary feed of the flotation plant?

A. They were richer.

X Q. 73. How do you know that?

A. By assay report.

1358 X Q. 74. About how much richer?

A. Oh, it would vary.

X Q. 75. From what to what?

A. From 10 to 20 per cent.

X Q. 76. You have also said that you were feeding this vanner concentrate into the flotation machine by buckets. I suppose the condition of the material in the buckets was about the same as mud, wasn't it?

A. Yes.

X Q. 77. How did you make a flowing pulp out of it?

A. Had a stream of water running into the agitator box.

X Q. 78. How long had you been working this way before you saw Mr. Nutter?

A. About three hours.

X Q. 79. And I take it that you had adjusted matters so as to get the best conditions, had you not?

A. It was impossible to adjust the machine to produce good results under the condition stated.

X Q. 80. Why was this?

A. The irregularity of feed.

X Q. 81. But you did the best you could, didn't you?

A. We did what we could under conditions.

X Q. 82. And you did as well as you could, didn't you?

A. Yes.

X Q. 83. Had you observed the condition of the flotation froth under these unusual conditions of feed? I refer to the period

1359 of three hours or so before you saw Mr. Nutter, and about or after that time, while these unusual conditions of feed were maintained?

A. Yes, I had.

X Q. 84. What did this condition show as to the oil, too much oil or too little oil?

A. It was impossible to tell, as the feed was irregular.

X Q. 85. It was too much oil part of the time, wasn't it?

A. Too much oil part of the time, and too little at other times.

X Q. 86. Prior to your employment in charge of one of the shifts at the flotation plant which you have described, what was your occupation?

A. Just prior to my employment as an operator of the flotation plant I was a timekeeper and clerk for the Butte & Superior Copper Company.

X Q. 87. And prior to that what was your occupation?

A. Millman, jigman.

X Q. 88. And how long were you employed as a millman or jigman?

A. About two and a half years.

X Q. 89. When you were started at your work in operating the flotation plant which you have described, was the plant shown to you in operation?

A. No.

X Q. 90. When you received the instructions that you have described, what was done to show you the conditions which you
1360 were to guard against, as well as the conditions which you were to produce?

A. I was shown the appearance of the machine when too much oil was applied, and when too little oil was applied, and the appearance when the proper amount was applied.

X Q. 91. And, of course, this was shown to you by the actual operation of the machine?

A. By the actual operation of the machine.

X Q. 92. And as to the amount of acid used, were you shown the conditions which you have described in the operation of the machine?

A. Yes, sir.

X Q. 93. Then, just what did you mean in your answer to X Q. 89, which I now show you?

A. Oh, I want to correct myself there. I understood that you meant previous to that time.

X Q. 94. You have said that too little acid made a lower grade concentrate. How would you know that the concentrate was of a lower grade?

A. By the appearance of the concentrate and by assays.

X Q. 95. What was the inside diameter of the oil feed pipe which ran from the oil tank to the agitator box?

A. I do not remember what it was.

X Q. 96. It was a small pipe, wasn't it?

A. I don't remember whether it was three-eighths or a half an inch.

X Q. 97. And is that inside or outside diameter? ?

1361 A. Inside.

X Q. 98. And about what was the inside diameter of the sulphuric acid feed pipe which ran from the pot of sulphuric acid to the Dewaterer?

A. It was either a three-eighths or half an inch.

X Q. 99. Now as to the oil feed pipe, generally the value was turned so as not to be wide open; that is true, isn't it?

A. Yes, sir.

X Q. 100. And this, I suppose, is also true as to the acid feed pipe?

A. It is.

X Q. 101. In this flotation plant, did the pulp flow directly into a spitzkasten from the agitating box of the same unit?

A. Yes.

X Q. 102. And where was the opening located through which it flowed?

A. At the bottom of the agitator box.

X Q. 103. About how wide was the opening?

A. I don't know exactly.

X Q. 104. About how wide was the spitzkasten, inside dimension?

A. I don't know how wide it was.

X Q. 105. I hand you a rule and ask you to indicate from memory about what was the width, inside dimension, of a spitzkasten?

A. Oh, 18 or 20 inches.

X Q. 106. Now also please, from memory, tell me about how wide the opening was from the agitating box to the spitzkasten.

A. About 4 inches.

1362 X Q. 107. And there was only one such opening?

A. Only one.

X Q. 108. And about how high was the opening?

A. It was about 4 inches high, and the same width.

X Q. 109. And was the agitator box the same width as the spitzkasten?

A. It was about the same width; I would say that it was exactly the same.

X Q. 110. Was there any inclined deflector in the spitzkasten just over the opening from the agitating box to the spitzkasten?

A. No.

X Q. 111. Was the wall or partition between the agitator box and the spitzkasten straight up and down and vertical above the opening which you have described?

A. It was.

X Q. 112. You have said that the tailings from the first spitkasten went to the first agitator box of the second cell or unit. What conducted it from the spitzkasten to this next agitator box?

A. A centrifugal pump.

X Q. 113. Where was this centrifugal pump located?

A. At the back of the machine.

X Q. 114. Was there a separate centrifugal pump for each connection from a spitzkasten to the next agitating box?

A. No.

X Q. 115. Please now more particularly describe the complete connection for the tailings from one spitzkasten to the next agitator box.

1363 A. Between which units?

X Q. 116. First the connection from the first unit of the roughing machine to the agitator box of the second unit.

A. By means of a centrifugal pump.

X Q. 117. How did the pipe run?

A. From the lower part of the spitzkasten through the centrifugal pump, a pipe leading from the outlet of the centrifugal pump into the first agitating box of the second unit.

X Q. 118. Where did this pipe enter the agitating box of the second unit?

A. At the top.

X Q. 119. Now please describe the connection for the tailings from the spitzkasten of the second unit to the agitator box of the third unit.

A. By gravity and a hydraulic lift.

X Q. 120. How was this hydraulic lift imparted?

A. A small pipe led into a tee and carried water under pressure. That water would force the pulp into the next agitating box.

X Q. 121. And where did the pulp enter this last agitating box, top or bottom?

A. Bottom.

X Q. 122. At the center or at the side?

A. About the center.

X Q. 123. Now how about the levels of the three spitzkasten of the roughing machine?

A. The first two were on a level; the third being lower than the other two.

1364 X Q. 124. As I understand it, the froth flowed from these three spitzkasten into the same launder?

A. Yes, sir.

X Q. 125. Now, as I understand you, in this roughing machine there were three agitator boxes in the first unit; is that right?

A. Yes, sir.

X Q. 126. And how many agitator boxes were in the second unit?

A. Two.

X Q. 127. And, of course, in the third unit there was one?

A. One.

X Q. 128. Now please, if you can remember, tell me how many spitzkasten there were in the cleaner machine.

A. Two.

X Q. 129. And how many agitator boxes in the first unit in this machine?

A. I am not positive, but I think there were three.

X Q. 130. And how many agitator boxes in the second unit in this cleaner machine?

A. One.

X Q. 131. Now how were the tailings conducted from the first spitzkasten of the cleaner machine to the agitator box of the second unit of this machine?

A. By gravity and by a similar hydraulic lift to the one I have already described.

X Q. 132. Did the water under pressure for this hydraulic lift flow from the same source as for the other hydraulic lift which you first described?

1365 A. Yes, they were both connected to the same supply pipe.

X Q. 133. And how was the pressure generated for this feed?

A. It was a gravity feed.

X Q. 134. Now how were the tailings conducted from the second spitzkasten of the cleaner machine to the second cell or unit of the rougher, to be retreated?

A. Through a pipe to the centrifugal pump, which took the tailings from the first unit to the second unit.

X Q. 135. And how was this centrifugal pump driven?

A. By a belt.

X Q. 136. You have said that the condition of the oil when you received it for use in the flotation plant was that of a solid mass. Was it always in this condition?

A. Yes, sir.

X Q. 137. Then did you have to put it into the oil box in chunks?

A. Yes.

X Q. 138. And in what sort of a receptacle was this oil delivered to you for use?

A. In wooden barrels and iron drums.

X Q. 139. Was this flotation plant operated continuously by three shifts of men?

A. It was, except when it was down for repairs or when the mill was down.

X Q. 140. Who were the two other shift foremen or operators?

1366 A. T. C. Wilson and Thomas Byrnes.

X Q. 141. Have you any idea of the capacity of that flotation plant, working twenty-four hours a day?

A. I have not.

X Q. 142. Was any complaint ever made to you of not having operated the plant to full capacity at any time while it was in your charge?

By Mr. Kremer: Objected to for the reason that it is incompetent, irrelevant and immaterial, improper cross-examination, and if answered, would neither prove nor tend to prove nor disprove any issue in this case.

A. Never anything said to me.

X Q. 143. Was there ever any complaint made to you that your concentrate was of too low a grade?

By Mr. Kremer: Objected to for the same reasons last interposed to X Q. 142.

A. Yes, there was, at times.

X Q. 144. I presume there was more complaint at the beginning of your work than after you had had considerable experience with the plant; is that true?

By Mr. Kremer: Same objection as last interposed.

A. Yes.

X Q. 145. Please describe the positions of the shafts of the agitators in the agitator boxes; that is to say, were they in the middle of the box or off to one side.

A. They were in the center.

Cross-examination closed.

1367 Redirect examination.

By Mr. Kremer:

R. D. Q. 146. Was there any additional oil or acid put into the concentrates after they left the rougher and went to the cleaner?

A. That was tried for a while, but abandoned.

R. D. Q. 147. And then it was operated in what manner, with or without?

A. Without.

R. D. Q. 148. Was the overflow of concentrates regulated differently on the two machines; by that I mean the rougher and the cleaner; if so, how?

A. Yes, it was.

R. D. Q. 149. How?

A. There was a large amount of water in the concentrate coming from the rougher, and no water in the concentrate from the cleaner.

R. D. Q. 150. By that I presume that you mean no free flowing water?

A. Yes.

Redirect examination closed.

Recross-examination.

By Mr. Williams:

R. X Q. 151. When was the change made in abandoning the use of additional oil or acid after the concentrates left the rougher and before they entered the cleaner, in relation to the time of Mr. Nutter's visit; before or after this visit?

A. I don't remember.

1368 R. X Q. 152. When additional oil was put in how and where was it put in,

A. In the first agitator box in the first unit of the cleaner.

R. X Q. 153. Where was the additional acid put in?

A. At the same place.

R. X Q. 154. Was there a separate tank for this additional oil, or did the pipe run from the one tank which supplied the rougher?

A. A separate tank.

R. X Q. 155. And how were the concentrates conducted from the rougher to the cleaner?

A. By gravity and hydraulic lift, the cleaner being lower than the last unit of the rougher machine.

R. X Q. 156. And, of course, this hydraulic lift added water at this point, didn't it?

A. Yes, sir.

R. X Q. 157. Now, as to the regulation of the fluid levels in the spitzkasten of the first unit of the rougher and the spitzkasten of the second unit of the rougher, how was this brought about?

A. Regulated by a valve.

R. X Q. 158. And where was this valve located?

A. The valve was located between the bottom of the spitzkasten and the centrifugal pump.

R. X Q. 159. Was there any other connection from the spitzkasten of the first unit directly or indirectly to the spitzkasten of the second unit?

A. None.

R. X Q. 160. You have testified of regulating the overflow
1369 of concentrates differently in the rougher and in the cleaner. Now, how did you regulate the overflow in the cleaner?

A. By valves in the same manner as we did on the rougher.

R. X Q. 161. Then, as I understand you, the difference was due to different regulation of the valves which controlled the flow of liquid or tailings from one unit to the next; is that correct?

A. Yes, sir.

R. X Q. 162. Was there any overflow regulation from the last spitzkasten of the cleaner other than in the pipe from this spitzkasten back to the rougher?

A. There was just the regulation of the inlet and outlet of that cell by valves in the pipe.

R. X Q. 163. You have said that there was a large amount of water in the concentrate coming from the rougher. Where was the fluid level maintained in the spitzkasten of the rougher to bring this about?

A. Above the level of the overflow lip.

R. X Q. 164. Now, in the cleaner you have said there was no water in the concentrate that flowed from it. How was this accomplished as to the position of the fluid level in each spitzkasten of the cleaner?

A. It was accomplished by keeping the water level slightly below the level of the overflow lip.

Recross-examination closed.

Deposition closed.

JESSE C. GIBSON.

1370 Subscribed and sworn to before me this 1st day of April, A. D. 1912.

CHARLES H. LITTLE,
Notary Public for the State of Montana, Residing at Butte, Silver Bow County, Montana.

My commission expires July 6th, 1913.

It is stipulated and agreed that the further taking of testimony upon behalf of defendant may be and is adjourned to such time and place, and before such Examiner as the court may direct or as counsel herein might agree upon.

1371 *Notary's Certificate.*

Certificate of Special Examiner.

United States District Court, District of Montana.

In Equity.

MINERALS SEPARATION, LIMITED, and MINERALS SEPARATION AMERICAN SYNDICATE, LIMITED, Complainants,

vs.

JAMES M. HYDE, Defendant.

STATE OF MONTANA,
County of Silver Bow, ss:

I, Charles H. Little, a Notary Public in and for the State of Montana, residing at Butte, Montana, hereby certify that the foregoing deposition of Jesse C. Gibson was taken before me at the office of Kremer, Sanders & Kremer, State Savings Bank Building, Butte, Montana; that said deposition of Jesse C. Gibson was taken on April the 1st, 1912; that for the purpose of taking said deposition I acted by agreement of counsel as Special Examiner under the 67th Rule in Equity as amended; that during the taking of such deposition the complainants were represented by their counsel, Henry D. Williams, Esq., and the defendant was represented by his counsel, J. Bruce Kremer, Esq.; that before said witness gave his deposition the said witness was duly sworn by me and his deposition taken down on the typewriter in the presence of counsel for both parties, and that, at the conclusion of his deposition, the same was signed by the
1372 witness in my presence.

I further certify that I am not of counsel for either party to this cause, nor related by blood or marriage to any member of either the complainant corporations or the defendant, and that I am not interested directly or indirectly in the matter in controversy.

In testimony whereof, I hereunto set my hand and notarial seal this 1st day of April, 1912.

CHARLES H. LITTLE,
Notary Public in and for the State of Montana,
Residing at Butte, Silver Bow County, Montana.

My commission expires July 6th, 1913.

1373 *Deposition of James M. Hyde.*

United States District Court, District of Montana.

In Equity.

No. 1076.

MINERALS SEPARATION, LIMITED, and MINERALS SEPARATION AMERICAN SYNDICATE, LIMITED, Complainants,

vs.

JAMES M. HYDE, Defendant.

Depositions of witnesses in behalf of defendant in the above entitled suit, taken by agreement of counsel before Joseph H. Blackwood, a Notary Public in and for the District of Columbia, acting by consent of counsel for both parties as Special Examiner, under the 67th Rule in Equity, as amended, at the office of Byrnes, Townsend & Brickenstein, 918 F street, N. W., Washington, D. C., beginning on Wednesday, April 24th, 1912, at 10 o'clock in the forenoon.

Appearances:

Henry D. Williams, Esq., for complainants.
J. Bruce Kremer, Esq., for defendant.
Walter A Scott, Esq., for defendant.

JAMES M. HYDE, a witness produced in behalf of defendant, having been duly cautioned and sworn, testified as follows:

Direct examination.

By Mr. Scott:

Q. 1. Please state your name, age, residence and occupation.

1374 A. James M. Hyde; 38 years; residence, Palo Alto, California; mining engineer and metallurgist.

Q. 2. Are you the defendant in this suit?

A. I am.

Q. 3. Please state briefly your education and experience in your profession.

A. I am a graduate of the department of geology and mining of the Leland Stanford, Jr., University, in which institution I was for one year instructor in assaying. I was for one year curator of the museum of the California State Mining Bureau, and for three years professor of mining and metallurgy in the University of Oregon. I have worked as a common miner, and as a mill-hand in all parts of amalgamating, concentrating, cyaniding and chlorination mills; have worked as an assayer and chemist, as superintendent of mines

and mills; as consulting engineer, and valuer of mines. I have been a student of processes for the treatment of different ores for the past fifteen years, and am the inventor of an improved process for the flotation concentration of ores, which is covered by U. S. patent No. 1,022,085.

Q. 4. Have you ever had any business dealings with Minerals Separation, Limited, one of the complainants in this suit?

A. On January 18, 1910, I received the following telegram:

"Can you come London, all expenses allowed in order to see process working and directors. If the directors are satisfied your ap-
1375 pearance will offer one thousand pounds sterling and expenses for a year in Mexico or elsewhere. Examination of properties.

"(Signed) HOOVER.

"Care Mineration."

This cable was sent to me by Mr. T. J. Hoover, who was general manager for Minerals Separation, Limited, one of the complainants. I had not heard from him for some two years' time, but was familiar, in a general way, with the business with which he was concerned, and cabled a reply, stating that I should leave for London, as requested, upon receipt of an advance sufficient to cover expenses of the trip. The advance was forwarded, and I left California about the 28th or 29th of January, and proceeded directly to London. In London, I was informed that a small private syndicate had been organized to search for mining business in Mexico, and that they would like to have me consider undertaking a search in that country, for special ventures for this syndicate. The Board of Directors were apparently satisfied that I was the proper person to undertake this work, after we had had our first meeting, for I was requested to outline a plan of campaign for the work. They immediately commenced to endeavor to persuade me to give them a contract for two years of my time, and it took me over two weeks, during which we were discussing matters and going over reports on Mexican properties, to persuade them that my determination to contract for but one year's time was final and unchangeable.

1376 I stated to them the reasons which led me to consider it extremely undesirable to contract for more than one year's time, which were in part as follows: That I would not undertake any long-term contract which would require me to be separated for long periods from my family; that Sr. Ezequiel A. Chavez, assistant secretary of education for the Republic of Mexico, had requested me to hold myself in readiness to undertake, so soon as opportunity could be arranged, the outlining and development of a system of industrial education for the people of his country, and that this was an opportunity of which I should wish to avail myself, if it took material form. Further, that a year might indicate to us that it was not wise to attempt to do business together further, and that during that year I should come into possession of an inheritance which,

supplementing my own earnings and savings, would permit me to operate independently, upon a modest basis. It was with a full understanding of these matters that the employment for a year's time was mutually agreed upon.

While this matter was under discussion, I visited the test works in London, and was shown the method by which small and larger lots of ore were tested by the processes practised by the company, and also made a trip to South Wales, to witness some tests of the flotation process which was being tried out on ore which had been shipped to England from the San Francisco del Oro mine in Mexico. These tests were not very instructive, as Mr. Hoover and the attendant in charge informed us that the results being obtained were very
1377 unsatisfactory. Upon my return to London, I came to an agreement with the Board of Directors that I should enter their employ for one year's time, and the chairman of the company, Mr. John Ballot, addressed a letter to me dated the 2nd of March, 1910, which reads in part as follows:

"James M. Hyde, Esq., 62 London Wall, E. C.

"DEAR SIR: As explained to you a private syndicate has been formed in connection with my company for the special purpose of exploring the Republic of Mexico, with a view to finding mines, ores, dumps or tailings, preferably amenable to profitable treatment by the Minerals Separation process, and to endeavor to acquire such mines, ores, dumps or tailings, wholly or in part, if such can be done on sufficiently advantageous terms, or to secure the adoption of Minerals Separation processes by mine owners, under royalty, in cases where a direct interest cannot be acquired—and if successful, to form a larger company to handle the interests so acquired.

"To give effect to this, and after fully discussing the policy with your goodself, it has been agreed to retain you to give your services exclusively, to make the necessary investigations in Mexico,
1378 and to carry out the object and intention of the syndicate to the best of your ability on the following terms and conditions:"

Then follow the terms and conditions as shown by the letter which I now produce.

To quote further from the letter:

"For the purpose of this understanding and to enable you to test ores on the spot, Minerals Separation will disclose to you its various processes, and give you all information in connection therewith, you undertaking to keep all such information confidential, and not to make use of any of it for any purpose except that of the syndicate, and further you undertake and agree to communicate to that company any ideas for improvement, modification or addition to the processes, mechanical or otherwise, which may occur to you, or which you may make, and such shall be the sole property of the Minerals Separation, and you will immediately, or whenever called upon, sign all documents necessary to protect the same by patent, if so

desired, and to convey the title to that company by assignment or otherwise."

At the testing works, I was shown the bottle test referred to by Mr. Nutter, in his testimony in this suit, which I recognized to be the exact test given by Alcide Froment in his British patent No. 12,778, accepted on June 4, 1903; and also certain tests which were conducted by agitating finely pulverized ore, water, sul-
1379 phuric acid and some oily substance, in a rectangular wooden box having two glass sides, through which the operations being carried on within could be observed. This apparatus was used as follows:

Ore, water, a small amount of sulphuric acid, and a small amount of some oily substance, were agitated together by an impeller, rotated upon a vertical shaft, suspended from above and without the vessel. When the agitation was completed, the mass was allowed to come to rest, when a considerable amount of floating mineral could be seen upon the surface in the form of a froth. The material was then re-agitated while the contents of the vessel were drawn out through an aperture at the bottom, and spread out upon the apron-plate of an overflow settling box, the oiled mineral matter floating off as a surface film while the gangue and some of the metalliferous mineral sank to the bottom and was drawn off and retreated upon a device similar to the one from which it was drawn.

Mr. T. J. Hoover, consulting metallurgist and general manager of the company, told me that this test did not represent the processes as actually operated by the company, but was the nearest approach to it which they had been able to devise on a small scale, and asked me to co-operate with him in devising a form of apparatus which would give results duplicating those obtained in the frothing process as developed in Australia, so that I might have a machine with me by which could be duplicated the results to be expected of the frothing process, as developed in Australia.

1380 Together, we designed a machine similar to and probably the same as the machine referred to as the slide test machine by Dr. Chandler and Mr. Nutter, in their testimony. I had several of these machines built in London and remained in the city long enough to develop a system of tests by the use of this apparatus and to instruct Mr. Wilkinson, an attache of Minerals Separation, Limited, in the use of this apparatus.

I proceeded to the United States and thence to Mexico, and devoted the year to a search for such properties as might be worked to a profit by the Mexican Syndicate.

By Mr. Williams: It being noted that the telegram of Jan. 18, 1910, referred to by the witness, was a code telegram, it is requested that it be marked for identification, subject to production upon request.

It is also requested that the letter dated March 2, 1910, referred to by the witness, be marked for identification, subject to production upon request.

By Mr. Kremer: The telegram and letter referred to may be marked for identification and may be produced upon request of counsel.

Q. 5. What was the principal difference in the operation of this small experimental machine which was in use when you went to London, and the one which you and Mr. Hoover designed?

A. There are two methods by which particles of metalliferous mineral which has been covered by a bare film of oil or some oily substance may be made to float upon the surface of the water.

1381 The first of these is by what is called surface tension—when the mineral particles float upon the surface of the water in a layer or film which is not more than one mineral particle in thickness or depth, as a greased needle will float upon water. A second method is by attachment of these mineral particles around gas bubbles which float upon the surface. The apparatus as used in London, when I arrived there, was so arranged that when the matter which had been agitated in the agitating box was discharged upon the apron of the overflow settling box, the oiled mineral particles flowing down the inclined apron were exposed to air and floated off as a film upon the surface of the water. This was necessitated by the method of discharging the agitated matter through a small opening well at the surface above the water. The apparatus designed by Mr. Hoover and myself was so arranged that when a material had been sufficiently agitated to oil the metalliferous matter, agitation ceased, the oiled mineral matter with gas bubbles attached floated and was removed as a floating froth by sliding off the top half of the material and discharging its contents into some receptacle.

Q. 6. Did you complete your year's employment with the Minerals Separation, Limited, as you agreed to?

A. I did.

Q. 7. What did you do in the practice of your profession immediately after leaving their employ?

A. Immediately after leaving the employ of Minerals Separation, Limited, I accepted an appointment as consulting engineer for the Oroya Exploration Company, with offices at No. 1 London

1382 Wall Bldgs., London, and prepared to stay in London for some time, giving my time to consulting engineering work, etc. I cabled to the United States to have my wife join me, and she replied that it would be unwise for her to do so for some time, on account of the condition of the health of our only child. I therefore planned to return to the United States at the earliest opportunity.

Q. 8. What knowledge did you have of oil flotation processes at the time you entered the employ of Minerals Separation, Limited?

A. I had for years made a close study of all that appeared in the technical press with regard to new methods for the treatment of ores, and had read everything which had appeared upon this subject in the Engineering & Mining Journal, Mining and Scientific Press, and other current literature, and was thus familiar with the work done by the Elmores and others, and by the group who were working in the Broken Hill field.

Q. 9. At the time you entered the employ of Minerals Separation, Limited, or while so employed, did you make any study of the patent situation from the legal point of view?

A. As my time was devoted to the search for material which could be acquired by purchase, lease or otherwise, I gave very little study to the legal phases of the situation. I remember having read some part of the record of the suit filed against Minerals Separation, Limited, by the Elmores.

1383 Q. 10. Did your duties while employed by the Minerals Separation, Limited, require you to be conversant with the patent protection which they might have or were going to have?

A. They did not. They made very broad claims to me as possessing monopolistic rights for the use of all flotation processes which involved the use of small amounts of oil, but, as I was specifically warned by them against seeking royalty business, except as a last resort, I never had occasion to prepare myself to defend their rights in matters involving infringement of patents, etc.

Q. 11. After leaving the employ of Minerals Separation, Limited, did you investigate any patents bearing upon flotation processes, and, if so, when and to what extent?

A. After leaving the employ of Minerals Separation, Limited, in order to assure myself as to the actual status of the patent situation in regard to flotation processes, I read over all of the patents relating to this subject which I could acquire or obtain access to, and made as careful study as possible of the subject-matter covered by them.

Q. 12. What conclusion did you arrive at as a result of the study of these patents?

Objected to by Mr. Williams, as incompetent.

A. I arrived at the conclusion that the only patents which were significant, which had ever been granted upon the subject, so far as I could learn, were the American patent, granted to Carrie J.

1384 Everson, No. 348,157; the British patent No. 12,778, accepted June 4, 1903, granted to Alcide Froment, and the Elmore vacuum process patent No. 826,411.

The Everson patent referred to was important as broadly disclosing the preferential oiling of mineral particles by oils and fats and derivatives thereof; the intensifying of this selective action by the use of an acid; and the possibility of separating the particles of metalliferous minerals from the gangue, either by building them up into an agglomerated mass, which will not float, or by causing them to float as the result of oiling and agitation. The Froment patent disclosed the fact that metalliferous mineral particles, which have been slightly oiled, will attach themselves to and can be floated by gas-bubbles. The Elmore patent cited is important as showing an ingenious method by which gas-bubble flotation can be effected. To my mind, the Everson and Froment patents disclose the whole basis upon which the art of flotation concentration has been developed.

By Mr. Williams: Reference to the Elmore vacuum process patent No. 826,411, is objected to as incompetent, for the reason that this

patent is not set up in the answer as an alleged anticipation, and it is further noted that it appears upon the face of the Elmore patent that the application for this patent was filed July 10, 1905, whereas the application for the patent in suit, as appears upon the face of that patent, was filed prior thereto, on May 29, 1905.

1385 Q. 13. You have referred to a testing apparatus in use by Minerals Separation, Limited, prior to the time you and Mr. Hoover designed the slide test machine. Were you told what the purpose was of having the test machine of the type used before the making of the slide machine?

A. Mr. Hoover informed me that when he went into the employ of Minerals Separation, they were attempting to carry on a flotation process by the use of an apparatus consisting of an agitator or series of agitators similar in type to the one illustrated in the cut shown in the patent in suit, the ore treated being first agitated in these vessels and then delivered through a pipe to an overflow settling box substantially as in the test apparatus which I have referred to as having been shown to me in London, which test machine therefore practically duplicated the operations which were attempted upon a commercial scale in the device just referred to. Consequently, this test machine would give a fair idea of what could be expected of the type of treatment machine which it substantially duplicated.

By Mr. Williams: The answer is objected to as hearsay and incompetent, and notice is given for a motion to strike it out.

Q. 14. Did you receive any instructions from those connected with Minerals Separation, Limited, regarding the practice of any oil flotation process?

A. The only definite instruction given me was that a preliminary idea could be obtained of the results obtainable in the treatment of an ore by making the bottle test, which has previously been
1386 referred to, and by carrying out a series of tests in the slide machine, in order to determine what oily substance would be best adapted for use with a particular ore. I was not instructed in detail with regard to the use of large testing machines further than that in all cases it was necessary to run varying the conditions as to amount of oil and acid used until such quantities were determined upon as gave the best results.

Q. 15. Did the Minerals Separation, Limited, or those connected with it, instruct you that in actual commercial operations you were to use apparatus like that shown in the patent upon which this suit is based?

A. I was informed by the engineer of the company that apparatus of the type of that shown in the illustration of the patent in suit had proven unsatisfactory and had been abandoned.

By Mr. Williams: The answer is objected to as hearsay and incompetent, and notice is given for a motion to strike it out.

Q. 16. While in the employ of Minerals Separation, Limited, did

you see their process or any of their processes carried out upon a practical commercial scale?

A. I did not see any commercial operations carried on in which any process to which they claimed ownership was used on a commercial scale.

Q. 17. When your year of employment by Minerals Separation, Limited, came to a close were there any negotiations looking toward a continuance of your connection with that company?

1387 A. Toward the end of my year of work, I received a communication from the chairman of the company asking me to undertake work outside of the Republic of Mexico, and work of such a nature that it would require more time than was left in the one year which I had contracted to give to their service. I therefore cabled to him reminding him that I had refused to contract for more than one year's time and asking where and when he proposed to discuss with me the question of further service. In reply to this telegram, I was requested to leave New York for London at an early date, and did so, arriving in London a day or two before Christmas day of 1910. I was asked to outline a plan upon which we could work together for a greater length of time, being told that an American Syndicate had been formed to carry out such a search for business upon the whole American continent, as had been undertaken in Mexico by the Mexican Syndicate. I submitted a memorandum outlining such plan which was considered by the members of the board of directors and discussed with me in particular by Mr. Francis Gibbs, Jr., one of the directors. A discussion of this matter was going on, with all probability that I should enter into another contract with the firm, when I determined that it was not wise for me to continue longer with them, withdrew the memorandum referred to, and handed in a letter formally severing my connection with the firm.

By Mr. Williams: The entire answer is objected to as incompetent, and notice given of a motion to strike it out. It is further
1388 noted that the communications referred to, the memorandum outlining the plan of the witness referred to, and the letter severing connection with Minerals Separation, Limited, referred to, are apparently capable of production, either by originals or full copy thereof, and therefore all reference thereto and attempt to epitomize the contents thereof, are secondary and incompetent, and in the absence of the best evidence as to these matters, notice is given of a motion to strike out this answer.

Q. 18. Have you the several letters and other communications to which you have referred?

A. I have the originals of communications received by me and copies of communications presented by me to the company. Also a letter, which would complete the series, in answer to my letter of resignation.

By Mr. Scott: The letters, cablegrams and copies referred to by the witness, in his answers to the two preceding questions will be marked for identification, subject to production upon request.

Q. 19. Was there any particular reason that influenced you in concluding not to continue your connection with Minerals Separation, Limited, after the expiration of the year you had agreed to work for them?

A. There was.

Q. 20. What was the reason?

A. Mr. T. J. Hoover, who had been acting as consulting engineer for Minerals Separation and occupying an office with them, decided to move to another office and devote but a portion of his time
1389 to the firm after the 1st of January, 1911. It was understood when he moved from Minerals Separation's office that the company desired that he should continue to act in a consulting capacity for them, and that he was willing to do so, upon certain terms and considerations. When he moved to the new quarters in which he established himself, he moved hurriedly, at the request of Dr. Gregory of the Board of Directors that he give him his office room as early as possible, and in moving, took to his new office a case containing a file of papers which included the accumulation of his own correspondence and notes for years, and also such reports as had been handed in to him while acting as consulting engineer for Minerals Separation, and which it would be necessary for him to have at hand, if he continued to act in that capacity. After he had removed his furniture, etc., from the offices occupied by Minerals Separation, Limited, a discussion arose between himself and the company as to the terms on which he was to continue to act in a consulting capacity for them, and taking offense at the terms which he proposed, the directors of the company, by telephone, demanded that he immediately turn over to them all documents relating to their business which were in his possession; as these were scattered through a great mass of personal material, it would be impossible to remove them at once and he replied that he was leaving for Russia, would not have time to attend to the matter before he left, but would do so immediately upon his return. The officers of the company, knowing that he was out of the city, brought an injunction
1390 against him, to prevent him from turning over the "documents and secret information of great value" to anybody other than themselves, and sent officers of the law to his house to serve such notice upon him. Although this was an ex parte proceeding, a type of action which almost never is allowed to appear in the public press in England, the two great financial dailies of the country contained accounts of the matter the next morning. During Mr. Hoover's absence from the city I acted in his behalf with the Board of Directors, endeavoring to protect his interests and show them how unnecessary and unreasonable was the action which they had taken. In one of my conversations with one of the directors, Mr. Curle, he informed me in the presence of Dr. Gregory, also of the Board of Directors, that Mr. Hoover had been punished enough. I told him at the time that I was certain that that was the motive which had prompted the action which had been taken.

This whole affair led me to conclude that it was unsafe and unwise

to longer associate myself with people who would make such an unnecessary and unwarranted attack upon the engineer to whom more than to anyone else was due the success of such operations as they had been engaged in.

By Mr. Williams: It now appearing that the reason called for is not a fact capable of proof in the manner stated, notice is given of a motion to strike out the entire answer, as incompetent.

1391 Q. 21. Did you ever state to Mr. Edward H. Nutter that you had accepted employment by Minerals Separation, Limited, for a year only, so that you would be free at the end of that period to make a more favorable contract with the company for your further services or else to make use of your knowledge of flotation concentration for your own purposes?

A. In my answer to Q. 4 I have stated the reasons for not entering into a longer contract, which were my real reasons. I was never actuated by such a motive as referred to by Mr. Nutter, and never stated to him or to anyone else that I was.

Q. 22. How soon did you return to the United States after the expiration of your employment by Minerals Separation, Limited, and what did you do immediately after reaching the United States?

A. About the first of March, 1911, Mr. H. C. Hoover, with whom I was associated in the matter of the Oroya Exploration Company, decided to make a hurried trip to the United States. As my family could not join me in London, I decided to return to the United States with him, and did so, arriving in New York early in March. When we arrived in New York, Mr. Chester Beatty, with whom Mr. H. C. Hoover was associated in a number of ventures, informed him that he was about to send Mr. Kuehn to Butte, to make an examination of the Butte & Superior Copper Company's property, for Hayden, Stone & Company, who were considering buying a large part of the company's bonds. Mr. Beatty and Mr. H. C. Hoover had
1392 previously considered participating in financing this company in connection with Hayden, Stone & Company, I believe, and Mr. Kuehn had made a previous examination of the property. As Mr. Beatty and Mr. H. C. Hoover were offered a participation in a bond issue which was being considered, Mr. H. C. Hoover suggested that as I had nothing definite on hand, they would like to have me go along and assist Mr. Kuehn in preparing a report on the property, and also make some tests upon the ore, in order to determine what was the best method by which it could be treated, and what results could be expected, so that they might know what value to ascribe to the property in making their estimates which would determine whether or not they would participate in the bond issue. I went to Butte with Mr. Kuehn, assisted him in gathering all of the data necessary to make the report and in making the computations upon which a report should be based. No one connected with the Butte & Superior Company, was, to my knowledge, acquainted with the fact that I had any knowledge of ore concentration processes until this examination was completed. At the com-

pletion of the examination, Mr. R. M. Atwater, general manager of the company, arrived in Butte, to discuss his findings with Mr. Kuehn. When I was introduced to him, he told me that he had met H. C. Hoover in New York, and that Hoover had told him that I was on the examination and was familiar with concentration processes.

1393 By Mr. Williams: Notice is given for motion to strike out the first sentence of the answer, as incompetent, in that it states a conclusion arrived at by a third party.

A like notice is given of motion to strike out the third sentence of the answer as hearsay and incompetent.

A like notice is given as to the fourth and fifth sentences.

A like notice is also given as to the last sentence of the answer.

Q. 23. What caused you to first apply flotation treatment to the ore of the Butte & Superior Copper Company, either experimentally or otherwise?

A. Mr. H. C. Hoover asked me to determine for him if the ore was amenable to treatment by a flotation process.

By Mr. Williams: Objected to as relating alleged statements made by a third party, and notice is given of a motion to strike out as incompetent.

Q. 24. What did you do to ascertain whether the Butte & Superior ore was amenable to flotation treatment?

A. I had a local foundry in Butte make a test machine for me of substantially the same type as the slide machine which we perfected in London, and with this machine tested the ore.

Q. 25. Did you make any report of the result of your test, and if so, to whom?

1394 A. I reported the results of my tests direct to Mr. H. C. Hoover.

Q. 26. Did anyone else approach you for information on the treatment of Butte & Superior ores by the flotation process?

A. Mr. R. M. Atwater, the manager of the property, asked me to report the results of my tests to him, and Mr. Kuehn, who had made an examination, wired to me from New York, asking me to send him the results of my tests. To both I replied that my results would be reported only to Mr. H. C. Hoover, as I did not know what were the details of the negotiations which he had on with the company.

By Mr. Williams: Notice is given of a motion to strike from the answer the reference to communications, unless the original communications are produced, with a further reservation that the communications appear to be fundamentally incompetent.

Q. 27. Did you, at a later date, make any report to the Butte & Superior Copper Company regarding flotation treatment of its ores?

A. I did.

Q. 28. What was the result, if any, of a report which you so made?

A. I was requested by the company to install an experimental machine for them at Basin, Montana.

Q. 29. Did you install such a machine?

A. I supervised the installation of such a machine.

Q. 30. About when was this machine first operated?

1395 A. About the first of August, 1911.

Q. 31. Is this machine still in existence?

A. It is not.

Q. 32. How long was it operated?

A. Intermittently for probably between one and two months.

Q. 33. Will you explain how it happened to be destroyed?

A. After this test machine had proven that the new process which I had worked out could be successfully employed, a larger machine was built and this one was abandoned. During my absence from the plant, the experimental machine was dismantled, as it was desirable to send parts of it to Butte, to be used in equipping the wood-working shop of the Butte & Superior Mine, and the Basin Reduction Company, owners of the mill at Basin, were desirous to have the room occupied by the test machine, which was loaned by them temporarily, made again available for their uses.

By Mr. Williams: The part of the answer commencing with "as it was desirable" to the end of the answer being clearly incompetent, notice is given of a motion to strike it out.

Q. 34. Will you describe the construction and operation of the plant built at Basin, and started in operation about Aug. 1, 1911?

A. I have prepared from memory a rough sketch of this plant, which is lettered, and to which I will refer in describing the plant.

The plant as installed and used for experimental work at

1396 Basin consisted of two parts, a machine known to the operators as a rougher machine, and generally designated on the sketch as R. M., and a secondary or cleaning machine, designated on the sketch as C. M. The rougher machine, consisted of six agitating compartments and three overflow settling boxes. Five of these agitating compartments were built together in the form of a rectangular box divided by partitions into compartments. To this box were attached two of the overflow settling boxes. The remaining portion of the rougher machine consisted of one rectangular agitating compartment, connected with an overflow settling box. In each of the agitating compartments an impeller suspended and attached to a vertical shaft was provided to act as an agitator. The cleaner machine consisted of four agitating compartments and two overflow settling boxes. Three of the agitating compartments were built together in the form of a rectangular box, divided into three sections by partitions. To this box was attached one of the overflow settling boxes. The remaining portion of the cleaning machine consisted of one rectangular agitating compartment connected with an overflow settling box. In connection with the concentration machine proper were used two pulp-thickening tanks, in which the pulp to be treated was separated from as much clear or nearly clear water as possible, in order to prepare it for flotation treatment.

Referring to the sketch, I will trace the passage of the ore through the machine and pulp-thickeners while being treated. The
1397 material to be treated, which consisted of fine portions of the ore removed by classifiers from that portion of the ore which was treated by other devices, flowed to the pulp thickeners through the thin pulp launder marked T. P. L. to the pulp-thickener designated as P. T. A small amount of sulfuric acid was added to the pulp as it flowed to the pulp-thickener from the acid-pot, A. P., by means of a pipe, the flow being regulated by the acid-valve A. V. The thickened portion of the pulp, which was to serve as feed for the flotation machine, was drawn off from the bottom of the pulp-thickeners by the feed-valves F. V. and F. V.′, and flowed to the flotation machine through the feed launder F. L. The clear, or nearly clear, water flowed off to waste over the end of the pulp-thickener marked C. W. O. The feed launder F. L. discharged the ore to be treated into the agitation compartment A^1. Into this compartment live steam was discharged through the steam-pipe S. P., and red oil was fed from the oil-pipe O. P. The pulp, after being agitated in A^1, flowed through an aperture into A^2, in which it was further agitated, and from which it flowed through an aperture into A^3, in which it was further agitated. From A^3 the pulp flowed through a practically square opening into the settling box designated as S. $B.^1$ This settling box was so attached to the box containing the agitating compartments that the partition dividing A^3 from A^4 was opposite the center of the settling box. Over the discharge lip of the settling box S. $B.^1$, floating metalliferous minerals with consider-
able free-flowing water containing gangue minerals over-
1398 flowed continuously into the launder marked R. C. L. That portion of the pulp which was not drawn over the discharge lip into the concentrates launder flowed from the overflow settling box through the Valve V to a pipe leading to a pump marked Pump 1, by which it was elevated and discharged into the agitating compartment A^4, in which it was agitated further, and from which it flowed into the agitating compartment A^5 for further agitation. From A^5 it flowed through the square opening into the settling box S. $B.^2$, from the overflow lip of which the floating metalliferous matter with considerable free-flowing water containing gangue minerals was continuously discharged into the rough concentrate's launder. Through the Valve V′ that portion of the pulp which was to be further treated was discharged into a pipe, through which, by means of an hydraulic elevator and by force of gravity, it flowed into the agitating compartment A^6, from which, after agitation, it was discharged through a practically square aperture into the overflow settling box S. $B.^3$, from the discharge lip of which was discharged the last portion of the concentrate recovered from the ore, together with a considerable amount of free-flowing water carrying gangue minerals in suspension. By means of the valve V″, the tailings were discharged to waste. The concentrates drawn off over the discharge lips of the settling boxes of the rougher machine flowed to a pipe, through which they were forced into the first

agitator compartment A^7 of the cleaner machine by an hydraulic elevator. After agitation in A^7 they passed through an open-
1399 ing into A^8, and thence on to A^9, being agitated in each of these compartments, and flowed through a practically square opening into the settling box S. B.[4]. Upon the surface of the water in this overflow settling box, the concentrates piled up as a tenacious froth 3 or 4 inches thick. The water in this settling box was maintained at such a level by the manipulation of the valve V'''' that no free-flowing water overflowed from it, but the concentrates piled up and flowed over the discharge lip as a thick mass into the clean concentrate's launder C. C. L. A portion of the material which was not drawn over the discharge lip was passed on to the agitating compartment A^{10} through the valve V''', and a pipe through which it was forced by an hydraulic elevator. After being reagitated in A^{10}, the material passed through a practically square opening into the settling box S. B.[5]. When the amount of concentrates forming upon the surface of the water in S. B.[5] was sufficient to allow the semi-dry concentrates to be drawn off over the discharge lip without any free-flowing water, they were so drawn off as from S. B.[4]. When the amount forming was too small to allow this, no concentrates were drawn off over the discharge lip, the whole content of the machine being discharged through the valve V^4 into a pipe, through which it was forced by a steam jet to pump 1 and returned to agitating compartment A^4 for further treatment. The concentrates produced by the cleaner machine flowed through a pipe to pump 2, by which they were discharged into the shipping bin.

1400 By Mr. Scott: The sketch referred to by the witness is offered in evidence, and is designated as "Defendant's Exhibit Hyde Sketch of Experimental Machine."

Adjourned until Thursday, April 25, 1912, at 10 A. M., at the same place.

Met pursuant to adjournment. Present, counsel as before.

Direct examination of James M. Hyde continued:

Q. 35. In operating the experimental machine which you have referred to, how did you determine how much oil and acid to use?

A. The amounts to use were at all times determined by an observation of the results obtained and by varying the flow of acid and oil in such a way as to give what were apparently the best results obtainable.

Q. 36. Have you ever found any better means of regulating the amount of acid and oil than by an observation of the results secured?

A. I have never found any other means which can be made use of.

Q. 37. Did you ever see Mr. Edward H. Nutter in Montana?

A. I have met Mr. Edward H. Nutter in Montana on two different occasions, or rather at two different periods. While engaged in making the examination of the Butte & Superior property with Mr.

Kuehn, I met Mr. Nutter in Butte on a number of occasions, and later met him at Basin.

1401 Q. 38. At the times that you met Mr. Nutter at Butte and Basin, was he there, as you understood, as a representative of Minerals Separation, Limited, or Minerals Separation American Syndicate, Limited?

A. On both occasions, he informed me that he was.

Q. 39. You have stated that you at first refused to make a report to the Butte & Superior Company regarding the treatment of their ore, but that you finally did make such a report. What occurred to change your attitude in this matter?

A. I received word from Mr. H. C. Hoover that he was not to participate in taking up the bonds to be issued by the Butte & Superior Copper Company, that consequently he was not to be considered in the matter further. I was informed by Mr. R. M. Atwater, general manager of the Butte & Superior Copper Company, that his company had discussed with Mr. Nutter the matter of having Minerals Separation or the Minerals Separation American Syndicate take up the matter of the treatment of the Butte & Superior ores, but he had decided that it would be impossible for them to do business together. He requested me to test the ore and to tell them what could be done in the matter of treating it, and I agreed to make a report upon the matter to them.

Q. 40. When in England, in the employ of Minerals Separation, Limited, did you witness any tests made with a large testing apparatus owned by Minerals Separation?

A. I saw the tests which have previously been referred to as being made in South Wales. The large test machine in the London works was not being used at the time of my first visit to England,

1402 because of alterations which were being made in the plant. During the period of my second visit to England tests were being carried on in a special machine devised by Mr. Nutter, which machine I saw in operation one or more times, but I was informed that its results were not entirely satisfactory.

Q. 41. Are Mr. H. C. Hoover and Mr. T. J. Hoover related to each other?

A. They are brothers.

Q. 42. How long have you known them?

A. I have known Mr. H. C. Hoover since 1891 or 1892, and Mr. T. J. Hoover quite intimately since 1897.

Q. 43. You have referred to a U. S. patent upon a flotation process. When and how did you come to invent the process described in this patent?

A. I take it that you refer to U. S. patent 1,022,085, and shall formulate my answer accordingly.

While engaged in making tests upon small quantities of the ore of the Butte & Superior Copper Company in the small test apparatus which I had made at the foundry in Butte I was surprised to find that the concentrates obtained were not of as high a grade as I had anticipated from a careful study of the ore. I therefore examined the concentrates and found that they contained an apparently consid-

erable amount of free gangue particles. The thought occurred to me that if the froth which was first formed was retreated by itself, it would be possible to disentangle and drop out a considerable portion of this worthless material. I therefore took the froths obtained from
the treatment of a portion of the ore and after cleaning out
1403 the small test machine returned these froths to the machine,
together with a sufficient amount of water, and reagitated the mass thoroughly. The bulk of the metalliferous mineral again floated and, upon assay, was found to be of higher grade than the concentrates which had been produced by the procedure which I had previously followed. I followed this matter up, and found that whereas the concentrates produced without retreatment would contain from 48 to 51 per cent. of zinc, it was possible to raise the grade by retreatment in the small test machine to as high as 55 per cent. Consequently, when I came to build a test machine at Basin, I planned for a machine consisting of a rougher and cleaner, and planned to use the rougher to make as complete a recovery as possible, and the cleaner to raise the grade of the concentrates as high as possible.

When this machine was installed it was soon apparent that the best way to achieve the results desired was to maintain such an overflow of concentrates and free-flowing water over the discharge lip of the overflow settling boxes of the rougher as would insure the complete and rapid removal of all metalliferous mineral matter which rose to the surface of the water. This involved the overflow with the concentrates of a considerable amount of suspended gangue matter. The concentrates on the surface of the overflow settling boxes of the rougher machine were usually thin and light colored. It was found possible to pile up the concentrates upon the surface of the water in the overflow settling boxes of the cleaner machine to such a depth
that the water-level could be kept so low that there was no
1404 free flow of water over the discharge lip but a constant or
intermittent sloughing over of a thick froth of cleaned concentrates. It was soon apparent that the tailings resulting from the cleaning operation were too valuable to be thrown away and an arrangement was consequently made by which they could be carried back to the rougher machine and further treated.

As it was found very difficult under the conditions met at the mill to produce a pulp sufficiently thick to be advantageously treated, the thought occurred to me that sulfuric acid might advantageously be made to act as a coagulant of the slimes in the pulp-thickener, and thereby perform a useful and added function. This was tried and was found successful. The process as covered by the patent was therefore largely developed in the course of these experimental operations, the matters of manipulation, etc., being learned during the first few days in which we worked.

Q. 44. What is the composition of the ore of the Butte & Superior mine which you have treated by a flotation process of separation?

A. The ore varies so much in its content of its various constituents that it is impossible for me to give you a chemical analysis which would be typical of the whole mine. Mineralogically, the ore con-

sists of zinc blende, a small amount of galena, varying amounts of pyrite and copper minerals, which are usually very small in quantity, quartz, altered granite, in which most of the feldspars are kaolinized, and rhodonite and rhodochrosite (respectively the
1405 silicate and carbonate of manganese). The principal value of the ore is due to its content of blende or zinc sulfid.

Q. 45. In your experiments with the Butte & Superior ores have you made any observations of the quantity of oleic acid or other oil used in different experiments, and if so, with what result?

A. I have experimented in my small test machine, using 500-gram charges of ore with amounts of oil varying from .6 to 1 cc. to 9 cc., getting very satisfactory results with both the smaller and larger amount of oil, the oil referred to being the impure oleic acid or red oil used in the experimental plant at Basin.

A typical test with the use of a very small amount of oil gave results as follows: The pulp treated was a sample of ore from the mill which assayed 23.3 per cent. zinc; the concentrates obtained from treating a 500-gram portion of this ore weighed 204.9 grams and contained 52 per cent. of zinc; the tailings weighed 283.5 grams and contained 2.2 per cent. of zinc. This test was carried out in the slide test machine, using 2 cc. of a 50 per cent. solution of sulfuric acid and .65 cc. of oleic acid. The actual recovery of zinc in this case amounted to 91.4 per cent. As the specific gravity of the impure oleic acid used is approximately .9, the actual weight of impure oleic acid used was .585 gram. This is equivalent to 2.34 pounds per ton of ore.

In a test in which 500 grams of ore containing 20.3 per cent. of zinc was treated in the small test machine with 9 cc. of oleic acid, 1 cc. of concentrated sulfuric acid and approximately 1700 cc.
1406 of water at a temperature of 78° Fahrenheit, 217 grams of concentrates containing 46.5 per cent. of zinc were obtained, and 283 grams of tailings containing .6 of 1 per cent. of zinc. The weight of impure oleic acid used in this case was 8.1 grams, equal to a rate of 32.4 pounds per ton of ore. This is equal to 1.62 per cent. on the weight of the ore or 5.3 per cent. of the weight of the metalliferous mineral contained in the ore. The percentage of recovery of zinc in this test amounted to 99.4 per cent. as figured from the weight of concentrates and their assay value and as 98.4 per cent. when figured by subtracting the total zinc content of the tailings from the total zinc content of the portion of ore reated.

All assays quoted by me in discussing these tests were made by W. R. Hocking, of Butte, Montana.

I have tested the ore similarly with cotton-seed oil, using a sample which I obtained from the Fair Drug Company, of Butte, Montana, and getting phenomenally high recoveries with amounts varying from .27 of a gram to 18 grams per charge of 500 grams of ore or through a range of from 1.08 to 72 pounds per ton of ore.

Using .3 of 1 cc., or .27 gram, of cotton-seed oil in treating a 500-gram charge of ore containing 21.3 per cent. of zinc, I obtained concentrates assaying 50.6 per cent. zinc and tailings assaying 1.3 per

cent zinc. The percentage of recovery as figured by formula, was 96.3 per cent.

Using 5 cc., or 4.5 grams, of cotton-seed oil in treating 500 grams of ore of the same lot, I obtained concentrates containing 45.4
1407 per cent. zinc and tailings containing .8 of 1 per cent. of zinc, the indicated recovery being 96.5 per cent.

Using 10 cc., or 9 grams, of cotton-seed oil in treating 500 grams of ore of the same lot, I obtained concentrates containing 49.5 per cent. zinc and tailings containing .7 of 1 per cent. of zinc, the indicated recovery being 98.1 per cent. The amount of oil used in this case was equal to 5.6 per cent. of the weight of metalliferous mineral present in the parcel of ore.

Using 20 cc., or 18 grams, of cotton-seed oil in treating 500 grams of ore of the same lot, I obtained concentrates assaying 51.5 per cent. of zinc, tailings assaying 1 per cent. of zinc and an indicated recovery of 97.2 per cent. The amount of oil used in this test was equal to 11.2 per cent. of the weight of metalliferous minerals in the ore treated.

All of these tests with cotton-seed oil were made upon a sample of ore containing 21.3 per cent. of zinc. In each test 1 cc. of pure sulfuric acid was used, and, in all cases, the concentrates were recovered as a froth.

By Mr. Williams: It is noted that the tests above described by the witness not having been made in the presence of opposing parties, the observations and conclusions of the witness are objected to as not the best evidence, unless an opportunity is afforded to complainants to repeat these experiments by supplying the complainants with sufficient quantities of the ores used in the conditions in which
1408 they were used in these experiments, and also, if necessary, of the other reagents. With this reservation, no objection is made to the assay figures upon the ground that the man who made the assays is not produced as a witness.

Q. 46. About how much rhodochrosite does the material fed to the flotation plant at Butte contain?

A. I have never determined what the amount is.

Q. 47. Why did you use oleic acid in the test in the experimental machine at Basin in preference to other oily reagents?

A. When I commenced to test the Butte & Superior ore I investigated the sources of oil supply which were available. I learned that the only oil being produced anywhere in the vicinity was produced by Charles T. Perry & Company, of Helena, Montana, at their soap and candle factory. I obtained samples of the material which they produced and marketed under the name of red oil and tested the same. I also obtained from the agency of the Continental Oil Company in Butte samples of various petroleum oils and from Armour & Company, samples of various animal oils. I determined that Perry's red oil was more satisfactory than other materials available, and therefore made use of it. It is the only oil produced in the Rocky Mountain region, with the single exception of some petroleum products, which do not give as commercially successful results.

Q. 48. In the operation of the experimental machine at Basin, was there any evolution of gas from the pulp during this treatment?

1409 A. Both in the vicinity of the pulp-thickeners and the flotation machine, a decided odor of hydrogen sulfid was evident.

Q. 49. To what did you attribute the evolution of hydrogen sulfid?

A. I attributed the evolution of hydrogen sulfid to the reaction of sulfuric acid upon the very finely-divided blend or zinc sulfid in the ore being treated. This odor is frequently very pronounced immediately after adding sulfuric acid when making tests in the small slide test machine, and was so pronounced around the large experimental machine that it was commented upon by the workmen.

Q. 50. Is the odor of hydrogen sulfid of such a character or quality that you can definitely identify it thereby?

A. The odor of hydrogen sulfid is of so definite a nature that it can very easily be identified. I am so familiar with it, from the use of this gas in chemical work, that I think it would be impossible for me to mistake any other odor for the odor of this gas.

Q. 51. In your work with the flotation process, as you have described it, have you noted any evidence of the evolution of any other gas than hydrogen sulfid?

A. In all of the small tests which I have made in the slime machine, there has been a loss of a certain amount of ore as indicated by adding together the weight of the concentrates and tailings produced and comparing this sum with the weight of the amount of ore treated. This loss amounts to several grams, even when

1410 the greatest care is used in manipulation to avoid mechanical losses, and it has seemed to me that to account for it, it must be assumed that some portion of the ore is dissolved in the very dilute sulfuric acid solution in which the pulp is treated. The most soluble constituent of the Butte & Superior ore is the rhodochrosite or manganese carbonate. If any of this were dissolved, carbon dioxide would be evolved.

Q. 51*a*. According to your observations of the Butte & Superior ore, is the amount of manganese carbonate present sufficient to account for the loss or difference in weight between the material treated and the weight of the concentrates and tailings?

A. I have no definite data on the matter. I have examined many car-loads of ore as received at the mill and have never seen one which did not contain rhodochrosite, which is very conspicuous because of its pink color. This mineral is always a conspicuous constituent of the jig-concentrates, and it and the allied manganese mineral, rhodonite, are undoubtedly responsible for the 2.99 per cent. of manganese found by Dr. Chandler in zinc concentrates said to be from Basin.

Q. 52. In what physical condition is the oleic acid delivered to you by Perry & Company?

A. It comes to us in drums or barrels and is always in a solid or semi-solid condition. I have never seen a barrel opened in which it

was sufficiently fluid so that the whole content of the barrel could be poured out through the bung-hole.

Q. 53. In practicing the process which you have described,
1411 at Basin, is the oleic acid used in the solid form?

A. It is not.

Q. 54. What do you do to it?

A. It is heated and brought into a fluid condition before being used.

Q. 55. Do you consider it necessary to reduce the oleic acid to a fluid condition in order to make use of it in the flotation process?

A. I do.

Q. 56. Do you know of any oil flotation process that is applicable to all sulfid ores, or is it your observation that different ores require different treatment, or that some defy any treatment by this process?

A. I do not know of any process of oil concentration which is universally applicable to all sulfid ores. I have attempted to work out a successful method of treatment of ores containing very finely-divided chalcocite, copper, sulfid, trying many different types of reagents in different amounts, without being able to get commercially useful results. Many mixed sulfid ores containing sulfids of lead, zinc, iron and copper can be made to yield tailings very free from sulfid, but the resulting concentrate containing the different sulfids mentioned is scarcely, if any, more easily marketable than the crude ore from which it has been concentrated. My own experience is that there are comparatively very few ores which may be completely successfully treated by oil concentration alone.

Q. 57. In your investigations in Mexico, for Minerals
1412 Separation, Limited, did you find ores or tailings amenable to treatment by the methods contemplated by Minerals Separation, Limited?

A. If you will excuse me, I prefer not to answer that question, as my instructions from Minerals Separation were to give out no information with regard to the matters investigated while in their employ.

The Examiner notes that the following documents referred to by the witness in his answer to Q. 4 are marked for identification as follows:

Cable, Hoover to Hyde, January 18, 1910.

Letter, Minerals Separation to Hyde, March 2, 1910.

And that the following documents referred to by the witness in his answer to Q. 17 are marked for identification as follows:

Letter, Minerals Separation to Hyde, November 23, 1910.

Cable, Minerals Separation to Hyde, December 8, 1910.

Copy Cable, Hyde to Minerals Separation, December 9, 1910.

Copy Memorandum re the Managership of Minerals Separation American Syndicate, Limited.

And the following document referred to by the witness in his answer to Q. 18:

Letter, Minerals Separation to Hyde, February 1, 1911.

Direct examination closed.

1413 Cross-examination.

By Mr. Williams de bene esse:

Not waiving the objections and notices heretofore stated and given.

X Q. 58. You have stated that you are the defendant in this suit. Is it a fact that you are paying the expenses of the defense of this suit, or is some one else paying or contributing to the payment of these expenses, and, if so, who is thus contributing or paying these expenses?

By Mr. Kremer: We object to the question last interposed for the reason that it is improper cross-examination, has no bearing upon the issues in this case and seeks to elicit no testimony which can in any way bear upon the issues in the case, and is incompetent for all purposes, for the further reason that the question is directed to the personal affairs of the defendant, and is frivolous in so far as this action is concerned, and cannot, under any view of this case, be considered as directed to the merits of the case, and for the further reason that it is such a question as falls within the rules of this court providing penalties for the asking of same, and, at the time of interposing this objection, we desire to state that if this question is pursued, we shall be compelled to ask the court to invoke the rule above referred to and so made and provided, as to prevent the asking of such questions during the taking of testimony under such conditions as this testimony is here taken.

1414 By Mr. Williams: It is submitted that it is relevant and material whether or not the defendant has others in privity with him in the defense of this suit, more especially as the circumstances suggested the fact that the Butte & Superior Copper Company, Limited, is in privity with this defendant. It is further submitted that the complainants are entitled to know whether or not such privity exists, especially as the fact is of paramount importance in the enforcement of any orders that this court may make. No privilege appearing, an answer to the question is insisted upon.

By Mr. Kremer: Realizing that arguments have no place upon the record at this time, but being mindful of the fact that Butte & Superior Copper Company, Limited, is not made a defendant in this action, and of the fact that counsel for complainants is likewise aware of this fact, having drawn the bill of complaint herein, and also realizing that this court can and will find means of enforcing its orders and its rules, we renew our objections and again assert that the matter will be presented to the court in the manner indicated, for under these conditions testimony cannot be sought solely for the purpose of use other than in the pending cause.

A. I am paying the expenses of the defense of this suit with the exclusive right to use in the Butte district the process covered by my U. S. patent 1,022,085, that exclusive right being granted to the Butte & Superior Copper Company for such sum of money as

1415 is necessary to cover the expenses involved in the defense of this suit.

X Q. 59. By whom have you been employed as consulting engineer?

A. By the Guanajuato Consolidated Mining & Milling Company of Guanajuato, Mexico, and the Oroya Exploration Company, of London and Australia.

X Q. 60. During what period were you employed by the Guanajuato Consolidated Mining & Milling Company as consulting engineer?

A. I have not the exact date at hand, but I believe that it was during the year 1905.

X Q. 61. During what period were you employed by the Oroya Exploration Company, as consulting engineer?

A. I did special consulting work for the Oroya Exploration Company in the month of February, 1911.

X Q. 62. By whom were you employed as a valuer of mines?

A. I went to Mexico in 1905 or 1906 for Bewick, Moreing & Company, of London, England, where I worked with Mr. T. J. Hoover for a short period, in searching for mining ventures, my work consisting largely in sampling and figuring the value of mines. The work which I did in Butte, Montana, for Hayden, Stone & Company was of this nature, and the work done for Minerals Separation, Limited, was also of this nature. I have also done casual work of this type on small properties in California, Nevada and Oregon.

1416 X Q. 63. By whom and when were you employed as superintendent of mines and mills?

A. In the year 1907 I was for a period superintendent of the mill of the Canyon Milling Company, at Manhattan, Nevada, and also of the mill and mines owned or controlled by the Manhattan Ore Reduction and Refining Company, of Manhattan, Nevada.

X Q. 64. When did you graduate from the department of geology and mining of the Leland Stanford Jr., University?

A. In 1901.

X Q. 65. What degree did you receive?

A. The degree of Bachelor of Arts.

X Q. 66. When were you professor of mining and metallurgy in the University of Oregon?

A. During the academic years 1902 and 1903, 1903 and 1904, 1904 and 1905.

X Q. 67. What members of the board of directors of Minerals Separation, Limited, endeavored to persuade you to give them a contract for two years of your time, as referred to by you in your answer to Q. 4?

A. Dr. Gregory, Mr. Francis Gibbs and Mr. John Ballot, chairman of the company, Mr. Ballot being so insistent upon the matter that Mr. Gibbs and Mr. Gregory finally counseled him, in my presence, to push the matter no further.

XQ. 68. You have produced a letter dated March 2, 1910, and addressed to you, from Minerals Separation, Limited; I now show you a letter dated March 3, 1910, and ask you if this is your

1417 letter in reply and acceptance of the employment tendered in the letter produced by you?

A. It is.

The Examiner notes that the letter identified by the witness is marked for identification "Hyde Acceptance, March 3, 1910."

X Q. 69. I note that this letter refers to cable messages between Mr. T. J. Hoover and yourself, dated January 18, 20, 21 and 24, 1910. You have produced a cable message dated January 18, 1910. I now produce a cable message dated January 20, 1910, with a translation written thereon. Are these two documents the first two of the cable messages referred to in that letter?

A. I cannot absolutely identify this from memory. I have no copy of it in my files which are at hand.

X Q. 70. Have you any reason to doubt that this is not the message which you sent on January 20, 1910, to Mr. T. J. Hoover?

A. I have not.

X Q. 71. The next cable message referred to is dated January 21, 1910, and was sent to you. My copy of this message says "£100 will be telegraphed if you can leave during next week." Can you produce this cable message?

A. I do not think I can from the files which are at hand. These messages came to me while I was in San Diego, California, and in the hurry of getting away I believe they were left with papers which were stored there.

1418 The Examiner notes that no objection is made to the marking for identification of the cable message produced in answer to X Q. 69 as "Cable Hyde to Hoover, January 20, 1910," and the marking of the copy of the message referred to in X Q. 71 as "Copy Cable Hoover to Hyde, January 21, 1910," and the marking of a cable message now produced dated January 24, 1910, as "Cable Hyde to Hoover, January 24, 1910," and to the use of these documents in evidence with the same force and effect as if the witness had identified them, it being understood that the translation of the code words therein contained is in substance correct.

Adjourned until Friday, April 26, 1912, at 10 A. M., same place.

Met pursuant to adjournment.

Cross-examination of James M. Hyde continued:

X Q. 72. From the letter marked for identification "Letter Minerals Separation to Hyde, November 23, 1910," which you have produced, I quote the following:

"After attending to the above matters, please proceed to Butte, Montana, and there go into the Zinc situation with the same minute care which has attended your investigations of the various fields in Mexico. Also test the tailings and various products you can secure from the copper mines and mills, say as little about your connection as is consistent with getting information."

1419 Was not the Butte & Superior Copper Company an important element of the zinc situation in Butte, Montana?

A To the best of my knowledge and memory, the name of the Butte & Superior Copper Company had never been mentioned to me by anyone connected with Minerals Separation, Limited. I do not doubt that they knew of that property and of Senator Clark's adjoining property, from which zinc concentrates were being shipped to Beer, Sondheimer & Company for treatment, through Beer, Sondheimer & Company who were associated with them in the Mexican syndicate, in whose behalf I had been retained to give my services for one year exclusively in searching for ventures in Mexico. These two properties are an important feature of the zinc situation at Butte.

X Q. 73. As a matter of fact, the mines at Butte are principally copper, and the two properties that you have mentioned are about the only zinc mines. This is true, is it not?

A. The properties which I have mentioned are the most important producers of zinc in the Butte district, in which, until the last year or two, no attempt had been made on a large scale to make use of the zinc ores which occur in great quantity in a number of properties. In the Butte & Superior mine and Senator Clark's Elm Orlu mine, which is the mine I have referred to in my answer to the previous question, the zinc ore is of greater purity than in other parts of the district, but in one section of the district I understand that practically all of the mines contain considerable zinc, and I am
1420 informed by the officers of the Amalgamated Copper Company that many of the large copper producers contain notable amounts of zinc-bearing ore of such grade that they should ultimately be large contributors to the zinc output of the camp. It is my private belief that Butte will eventually become as important a factor in the zinc industry of the country as it is now in the copper industry.

X Q. 74. Please compare the documents which you produced as a copy of your "Memorandum re the Managership of Minerals Separation American Syndicate, Limited," the two documents which have been sent to me from the files of the complainants, marked by me A and B, and advise me which of these documents represents your memorandum as submitted to the directors of the complainant company?

A. After comparing the papers which you hand me, I note that there are differences between them and that the copy which you present marked A is not signed, as I believe was the final copy, or rather original, which I presented to Minerals Separation, and that the copy which I produced bears emendations which it is my memory were a part of my final communication upon this subject. I therefore conclude that the copy which I have produced is a true copy of my communication to the company upon this subject.

The Examiner notes that the documents which were produced in propounding the last question are marked for identification "A" and "B," respectively.

X Q. 75. Upon comparing the document marked "B" with
1421 the copy of the memorandum produced by you, they appear to be, in their typewritten parts, identical, but the document

marked "B" contains several blue-pencil deletions and a few black-pencil amendments. What is your recollection as to these deletions and amendments, and by whom were they made?

A. My memory is that this communication was discussed with Mr. Francis Gibbs, Jr., of the Board of Directors, and that certain changes from the original draft were suggested by him as likely to make the communication more acceptable to the financial associates of Mineral Separation, Limited, in the American Syndicate. I recognize that the pencil handwriting on these sheets is not my own and presume that the pencil handwriting was placed there by Mr. Gibbs.

X Q. 76. I now show you a letter apparently signed by you, dated January 17, 1911, and ask you if you identify this as the letter delivered by you to Minerals Separation American Syndicate, Limited, withdrawing your memorandum "re the Managership," and expressing your unwillingness to contract with the company for another year?

A. As I have in my file an exact copy of this letter and as the letter produced by you is apparently signed by my handwriting, I take it to be the original letter which I presented to the company.

The Examiner notes that the letter referred to is marked for identification "Letter Hyde to Minerals Separation American Syndicate, January 17, 1911."

1422 X Q. 77. In your answer to Q. 4, in paragraph beginning "I stated to them," and ending "mutually agreed upon," you state the reasons which led you to consider it undesirable to make a contract for more than one year's time. To whom and in whose presence were these statements made?

A. It is my memory that those reasons were given to one or more of the following persons Mr. John Ballot, Dr. Gregory and Mr. Francis Gibbs, Jr., directors of Minerals Separation, Limited. I think I also stated them to Theodore J. Hoover, who was at that time the company's Consulting Engineer, and, if I am not mistaken, General Manager.

X Q. 78. For how long a period after March 3, 1910, did you remain in England?

A. To the best of my recollection until the 8th or 9th of April of the same year.

X Q. 79. And then where did you go?

A. I then proceeded to New York.

X Q. 80. And during what period did you collaborate with Mr. T. J. Hoover in the production of the slide machine?

A. During the period in which I was in London. My departure from London was delayed by waiting for the slide machine to be built according to our first design, to be tested and then slightly modified.

X Q. 81. What equipment for testing ores did you have during your work in Mexico?

A. My equipment for testing ores while in Mexico consisted of

one or more slide machines sent to me from London and such
1423 dishes, stoves, etc., as I purchased in places where I worked, together with a small balance and miscellaneous small supplies purchased in El Paso, Texas, and such small motors as I was able to make use of in places where I worked.

X Q. 82. Did you make any bottle tests while in Mexico, using oil, acid and water, and finely-ground ore, and nothing else?

A. It is my recollection that I did, although I have never, while with Minerals Separation, made very many tests of that type, as I had the means at hand for doing quantitative work.

X Q. 83. A bottle test such as I have described is rather crude and inconclusive, is it not?

A. With proper manipulation, it is practically absolutely conclusive as to whether or not the sulfid contents of an ore can be made to float. In fact, this test was held in so high esteem by Minerals Separation, Limited, that Mr. T. J. Hoover, their chief technical adviser, assured me that it was useless for me to burden myself with heavy test apparatus, because this test would always give such an indication of what could be done with an ore that it was a safe guide as to whether or not an ore tested by it was worthy of further investigation and that it would be a saving of time to rely upon the London test works to make all quantitative tests, but in deference to the wishes of the Board of Directors that I should be able to report as to quantitative results obtained in the field, we considered it worth while to devise and make field use of the slide test machine. I be-
1424 lieve it possible to so manipulate this test as to get a fair idea of the probable percentage of recovery to be obtained with treatment of an ore by froth flotation.

X Q. 84. Is the test which I have described, in which nothing is added to the finely-ground ore except water, oil and acid, the bottle test which you have said you recognized to be the exact test given by Froment in his British patent 12,778 of 1903?

A. With the exception that this test is carried on in a bottle, whereas the test given by Froment was carried on in a test tube, a difference of no importance, I consider the tests to be absolutely identical in the case of the Butte & Superior ore or any ore carrying soluble carbonates, or any minerals upon which sulfuric acid may react with the formation of gas, as it does in the case of the Butte & Superior ore on the finely-divided zinc sulfid. Further, as Froment states that a gas of any kind may be liberated in the water or in the pulp, I believe that it would be impossible to carry out this test in the presence of a small amount of oil without entraining an amount of air with the oil which would surcharge the water with air, a certain portion of which air would not only be freed but, in a strict sense, absolutely liberated, in the pulp when agitation ceased, and the mass was allowed to come to a quiet condition. As stated by Mr. Nutter in his testimony, the entraining of air commences when the water surface is broken and coincidently with the breaking up and mixing through a wet pulp of oil which may be present. I have repeatedly shaken up water in a bottle or test tube with a

1425 drop of oil and have always found that the mass becomes milky white from the inclusion of air, which air continues to separate from the water for a considerable period after the agitation has ceased.

X Q. 85. Now assume a bottle test such as I have described with an ore not carrying soluble carbonates or any mineral on which sulfuric acid will react with the formation of gas, would such a test be the exact test given by Froment in his British patent 12,778 of 1903?

A. I am not able for the moment to call to mind any ore which would be amenable to treatment by a so-called froth flotation process which would not contain constituents which would be reacted upon by sulfuric acid. That zinc sulfid, as the mineral blende, when finely ground is acted upon by sulfuric acid with the formation of hydrogen sulfid, has already been stated. It is my belief that the other sulfids which it is possible to float as a froth are also so reacted upon, and I should consider that if the metalliferous minerals contained in an ore were by such a bottle test made to float as a froth the presence of the froth of which gas is an essential constituent would indicate that gas had been liberated in the mass during or after agitation. I would consider that any test such as you mention which produced a froth containing metalliferous minerals would be such a test as that cited by Froment in the patent referred to.

X Q. 86. And you had in mind, did you not, in answering the last question, the very highly dilute condition of the sulfuric acid in the bottle tests which produce a satisfactory mineral froth?

1426 A. The bottle test, as I have seen it used by Minerals Separation, always included the use of a few drops of sulfuric acid, which is exactly what Froment calls for, and was in that point always identical with his specifications, and, further, the solvent effect of the sulfuric acid was always made more pronounced than he specifically calls for by using a warm solution for the test. It is a well-established and commonly-known fact that warm solutions of acid are more active as solvents than are cold ones. As no definite specification was made in your previous question as to the amount of sulfuric acid used or the quantity of water or ore to which it was added, I assume that you were referring to the test as ordinarily made by the technical assistants of Minerals Separation, Limited.

X Q. 87. And by yourself, I take it, when you were working for them?

A. In such tests as I made while in the employ of Minerals Separation, Limited, I used such an amount of sulfuric acid as was required to give a result with the ore being tested, never measuring the amount with great care, but adding sulfuric acid until agitation either gave a froth, or until I was convinced that the ore being treated would not yield a froth.

X Q. 88. In the flotation separation apparatus used by you at Basin, Montana, what percentage of sulfuric acid was employed in the pulp solution which was fed to the first agitation box?

A. I have no absolutely definite information upon this point.

1427 X Q. 89. What was the consumption of sulfuric acid per ton of ore treated, on the average?

A. I never had any absolutely reliable information as to the exact tonnage of ore which was being treated, and can therefore not give absolutely reliable information with regard to the average consumption of sulfuric acid per ton of ore treated.

X Q. 90. Is it not a fact that the cost of the sulfuric acid is an essential element in determining the commercial value of such a process as you used?

A. It is, but the conditions under which the operations were carried out at Basin were such that it was not possible there to determine the actual commercial value of the process as practised.

X Q. 91. What is your present knowledge as to the cost or consumption of sulfuric acid per ton of ore in this process?

A. From reports prepared by Mr. Smith, who was taking samples while tests were being run with the experimental machine, it was indicated that the consumption of sulfuric acid amounted to from a quarter to a half-pound per ton of ore treated, when it was used in the particular way indicated in my patent and practised at Basin, that is, by being added previous to the thickening of the pulp.

The reason I have referred to the information as not absolutely reliable was because the calculations as to tonnage were based upon the weight of quart samples of the feed pulp which were taken from time to time, as was also the number of gallons per minute
1428 flowing through the plant. The percentage of solids in the feed was determined by reference to a chart prepared by Smith, giving the percentage of solids in a quart of pulp for different weights of the quart of pulp. The chart and method have since been demonstrated to be so unreliable that no common factor even can be used for corrections of its errors and the reports based upon such observations are so inaccurate as to be unworthy of consideration as evidence.

X Q. 92. What treatment was the ore subjected to prior to the entrance of the pulp into the pulp thickener, as you have designated it?

A. The crude ore coming from the mill was elevated to ore bins and fed through a jaw-crusher of the Blake type. From this it passed to a revolving trommel or screen, water being added to it at this point. Following the usual mill procedure, it passed through various stages of crushing and screening, rolls being used for the finer stages of the crushing, until it was all sufficiently fine to pass through a screen having apertures of seven millimeters diameter. It was then roughly classified, the slimes being sent to Callow cones to be thickened, the coarser portion of the ore passing to Foust jigs in which the coarser parts of the free mineral were removed from the poorer portion of the ore and recovered as coarse concentrate, two of these jigs being used in sequence, the rougher making rough concentrates and the cleaner making clean concentrates. The tailings from both of these jigs were further crushed by rolls until the whole product
1429 was passed through a screen having an aperature of 2½ millimeters. This material was then classified roughly, the fine slimes being sent to the Callow cones to be thickened, the sands be-

ing sent to other Foust jigs, which removed a certain amount of the free mineral as a sand concentrate. The tailings from these jigs being further crushed by a Chilean mill, after which by classification, they were divided into portions, the coarsest of which went to Hartz jigs, which made concentrates to be saved and tailings to be thrown to waste; a finer portion going to Wilfley tables which made shipping concentrates and tailings, the coarser portion of which went to waste, the finer portion going to vanners for further treatment; the slimes going to the Callow cones for thickening. The vanners made concentrate, of such low grade that it was found desirable to retreat them in the flotation department, and tailings which were thrown to waste. The thickened product from the Callow cones was the material which was led to the pulp-thickeners previously referred to and, after acid-treatment and thickening, became the feed for the flotation machine.

X Q. 93. When the pulp entered the pulp-thickeners in which you suggested the use of an acid treatment, about what was its condition as to thickness?

A. It was pretty dilute.

X Q. 94. And about what proportion of clear water was overflowed in these pulp-thickeners?

A. The water overflowing was in no place absolutely clear. The pulp-thickeners were too short to give the maximum efficiency. I have no reliable data at hand which I can quote in answer to this question.

1430 X Q. 95. Please answer, then, upon your general knowledge and observation.

A. It is my recollection that it was reported to me that the pulp flowing to these tanks contained 20 to 25 parts of water to 1 part of ore, by weight, and that the overflow going to waste contained from 60 to 100 parts of water to 1 part of ore, while the feed going to the flotation machine fluctuated between some such limits as from 3½ to 11 parts of water to 1 part of ore. Any more definite answer that I would give to your question would have to be based upon computations based upon these figures, and would necessarily be conjectural and inaccurate.

X Q. 96. I take it that you have no doubt that the pulp which was fed to your flotation plant and entered the first agitation box thereof contained less than 1 per cent. of sulfuric acid?

A. It is probable that it did not contain more than 1 per cent.

X Q. 97. It seems to me a reasonable conclusion that it contained much less than one per cent. of sulfuric acid. Do you agree with me as to this?

A. It is reasonable to so assume, but, as the amount of acid used in proportion to the ore treated was not accurately determined and was sufficient to cause such a reaction upon the ore as to make the odor of hydrogen sulfid apparent both at the pulp-thickeners and in the flotation plant, I would not feel justified in committing

1431 myself to any definite conclusion as to what amount was used in proportion to the amount of water or ore.

X Q. 98. What became of the sulfuric acid in the overflow from the thickener in which sulfuric acid was added to the pulp?

A. It passed off with the overflow water which flowed to waste.

X Q. 99. Referring now to the typical test first described by you in your answer to Q. 45, at what temperature was this test conducted?

A. I have no record of what temperature at which this test was made.

X Q. 100. What is your best recollection?

A. My best recollection is that while making the series of tests of which this is one, it was my custom to put into my machine the hottest water which was available, which was frequently at almost boiling heat, but which would be cooled by contact with the machine to a temperature of approximately 60-65° Centigrade. As this practice was not always followed, and I was performing many tests, I cannot say that I have any definite memory as to the conditions of temperature under which this test was made.

X Q. 101. You say that you used a sample of ore from the mill. Please more definitely describe the sample which you used.

A. My note-book bears the following record as a title to this test: "Slime Table Heads plus alum, four days." My recollection is that this is material which was collected over a period of four days' time as a sample of the material being treated by the Wilfley tables which were treating what was called a fine feed. This was the material which was later used as the feed for the flotation test machine. The reference "plus alum" refers to the fact that a very small amount of alum had been added to the pulp, as collected, in order to settle the slimes so that clear water could be turned off, and it would not be necessary to dry down the whole sample which filled several half-barrels. My tests have indicated to me that the use of alum in this way does not disadvantageously affect the results to be subsequently attained in treating ore by a flotation process.

1432

Adjourned until Monday, April 29, 1912, at 10 a. m., same place.

Met pursuant to adjournment.

X Q. 102. Continuing my reference to the physical test first described by you in your answer to Q. 45, please supplement your description, more particularly as to the speed of rotation of the agitator blades, the diameter thereof, and the period of time and the number of times the agitation was carried on, and any other particulars that may be necessary in order to reproduce this test.

A. I have no description in my notes of the exact dimensions of the test machine used, but, from memory, would state that the approximate width of the slide machine was probably 4 or 5 inches, the probable diameter of the impeller, 3 or 3½ inches. The impeller was a simple, cross-like metal agitator having two cross arms attached to a hub. These arms had a height of approximately one-half inch and a thickness of not over probably an eighth of an inch. This impeller was attached to a vertical shaft introduced into the agitating chamber through a stuffing-box or gland in the bottom of the agitating box, and was driven by an electric

1433

motor, power being transferred to it by a small belt. I have absolutely no record as to the speed, it never having been determined, and having varied through a considerable range at different times, because the motor was upon a moving block or board, and the belt frequently ran so loose that the full speed was not transmitted to the impeller. The agitation was brisk in most of the tests of the series from which this one is taken, the pulp was agitated for from twenty to forty seconds, when it was allowed to come to rest, and after the gangue material had settled sufficiently to show clear water through the window in the side of the machine, the concentrate floating in the upper portion of the machine was removed by sliding the upper half of the machine forward and emptying its contents into a pan. The upper portion of the machine was then pushed back into position, clamped into place, and sufficient water added so that about a quarter of an inch of water was visible through the window in the upper half of the machine. The operation of agitation and removing of froths was repeatedly performed so long as a material
1434 amount of concentrate was produced by each operation. The time of agitation was as before. Usually but two portions of concentrate were removed, a third agitation rarely giving enough added concentrate to be of consequence.

I believe that the manipulation just described was that by which the results cited in the test referred to were obtained. There is no record in my note-book describing this test more fully than to give a description of the material treated, the weight and assay value of the ore used, and the concentrates and tailings resulting from the test, the numbers which were attached to these when sent to the assayer, and the percentage of recovery indicated.

From memory I would state that the material treated was very fine—would all pass through a 60-mesh screen, most of it being fine enough to pass through a 100-mesh screen.

X Q. 103. You have not, in your description, stated the amount of water used originally in this experiment. What was this amount?

A. Approximately 1700 cc.

X Q. 104. Now referring to the second test described by you, in which you used 9 cc. of oleic acid, please supplement your description by such particulars as would enable us to reproduce the test.

A. The manipulation in this case was practically identical with that described in my preceding answer. The note-book contains this additional data: "3 froths, 1 film obtained, Result excellent." The oleic acid used in this case, I remember to have been from a
1435 sample of purer red oil which Charles T. Perry & Company, of Helena, Montana, had submitted to me in response to a request to submit sample of oleic acid or red oil with the lowest melting-point which they could produce in commercial quantities.

The red oil used in the test just previously described was from a sample of impure oleic acid, which they have regularly produced and marketed under the name of "red oil." This was the material used as oil in the test carried on with the experimental machine.

X Q. 105. Will you send me a specimen of each of these varieties of oleic acid used by you in these experiments?

A. I will arrange to have it sent to you from Butte.

X Q. 106. And will you also send me a specimen of the ore used in these experiments in the condition in which it was used therein?

A. I will arrange to have this duplicated, as nearly as possible, for you.

X Q. 107. Now as to the test wherein you used 0.3 cc. of cotton-seed oil, please supplement your description by such particulars as will enable us to reproduce this test?

A. The series of tests with cotton-seed oil were all carried out substantially as has been described in my answer to X Q. 102. I have no record in my notebook, and cannot state from memory definitely, as to the period for which the pulp was agitated in these tests, but my memory is that it was from twenty seconds to a minute. It may have been even more than a minute.

1436 The amount of water used was approximately 1,700 cc., the water was warm, but I have no record of its temperature. My note-book bears notes of these tests as follows, with a test in which 5 cc. of cotton-seed oil was used: "3 good froths, concentrates not cleaned"; with a test in which 10 cc. of oil was used, "3 froths, concentrates cleaned"; with a test in which 20 cc. of oil was used, "4 froths, last very small, concentrates cleaned."

The phrase "concentrates cleaned" refers to the fact that the concentrates recovered in the several successive treatments of the ore were united and returned to the test machine after the tailings had been discharged from it. To these was added enough water to make the total amount present approximately 1,700 cc., and they were re-agitated substantially as before, and the floating concentrates were removed. This operation was repeated one or more times. The tailings or middlings resulting from this operation were added to the tailings produced in the first treatment of the ore. It is possible that a drop or two of acid and oil were added during this retreatment of the concentrates, but I do not remember that this was done.

X Q. 108. Did you use the same slide machine in your cotton-seed oil test as in the oleic acid test?

A. The machine used was not the same machine, but was in duplicate, made from the same pattern in the same foundry.

X Q. 109. If required, will you produce one or both of these slide test machines, for the inspection of our experts and use by them, if necessary?

1437 By Mr. Williams: Counsel for defendant having stated that one of these slide machines, used by the defendant in his tests, will be introduced in evidence during the taking of this testimony, the question is withdrawn.

By Mr. Kremer: Counsel for complainant having submitted the statement that upon the presentation of the testimony of their expert, the slide machine used by their expert in the tests with reference to which their said expert may testify, will be introduced in evidence, the defendant now states that before the conclusion of their expert testimony one of the slide machines, being a duplicate of the other, will be introduced in evidence, for the inspection of the court.

X Q. 110. Referring now to your patent No. 1,022,085, I quote the following, page 1, lines 75-81:

"By following this method, I have been able to get highly satisfactory results when using as little as one-quarter of a pound of crude acid per ton of ore treated, whereas in previously-used methods, several pounds have been found necessary."

Again on page 3, in giving an example of use, the specification says, lines 101-107:

"To this pulp while in transit to the thickeners, was added an amount of commercial sulfuric acid equivalent to from one-quarter to one-half pound per ton of ore treated. At times a decided
1438 odor of hydrogen sulfid could be noticed around the pulp-thickeners."

In your answer to X Q. 91, you mention a determination of a consumption of sulfuric acid from a quarter to a half pound per ton of ore treated, and you say that this determination was so inaccurate as to be unworthy of consideration as evidence.

Are the quoted statements in your patent founded upon these unreliable and inaccurate observations?

A. At the time the application for the patent was drawn, and, in fact, until within the last thirty to sixty days, the data referred to in my answer to X Q. 91 was considered to be reliable, within the limits of error incidental to mill-sampling. The figures given in the patent were based upon the reports referred to in my answer to X Q. 91. The amount of sulfuric acid used, while very small, was sufficient to cause chemical action on the metalliferous minerals present, and was therefore a different amount from that specified by the patentees of the patent in suit, who particularly specified that they used an amount of acid "insufficient to cause chemical action on the metalliferous minerals present." The only evidence at hand as to the amount in pounds proportional to the tons of ore treated in the experimental plant, is that referred to in my answer to X Q. 91.

By Mr. Williams: The reference by the witness to the patent in suit is objected to as volunteered.

1439 X Q. 111. Then, as I understand you, the statements which I have quoted from your patent are inaccurate, unworthy of consideration as evidence, and, in fact, untrue?

A. The statements referred to are undoubtedly approximately true, but cannot be said to be scientifically accurate, and were therefore, in my answer to X Q. 91, not vouched for as acceptable as evidence, which I understand must be, in such matters, scientifically accurate.

X Q. 112. In describing the second oleic acid test referred to in your answer to Q. 45, and the third and fourth cotton-seed oil tests referred to in that answer, you give the percentage of oil to metalliferous mineral contained in the ore. What was the basis of that computation?

A. The basis of that computation was the blende contained in the ore, the amount of which can be arrived at by multiplying the assay of zinc by the factor 1.49. The amounts of other sulfids occurring in the ore were so insignificant that they were not taken into account.

X Q. 113. What was the cost of the impure oleic acid used at Basin in your flotation plant?

A. This was purchased by the business management of the Butte & Superior Copper Company, and I have no definite data at hand as to its cost.

X Q. 114. I take it, however, that you have made calculations in which this element of cost has been a factor. If so, what have you calculated it as?

1440 A. When I first learned that Charles T. Perry & Company were producers of impure oleic acid, I applied to them for information as to the price of the same. In one of my note-books I have a note under date of April 19, 1911, that that firm produced oleic acid which "sells in barrels at Helena, Montana, for from 4½ to 6½ cents per pound. The present price is 6⅛ cents, freight to Butte, probably ¼ cent." My memory is that in my calculations, I have used 6½ cents per pound.

X Q. 115. Now as to the cost of the sulfuric acid used. How have you computed that?

A. I have assumed, from quotations obtained from an acid company in Denver, Colorado, that 93½ per cent. acid would cost approximately 1½ cents per pound, when delivered in tank cars, and 3 cents per pound when delivered in drums.

X Q. 116. I note that your witness, Jesse C. Gibson, testified that he had charge of the operations of the flotation plant from the latter part of July, 1911, up to about February 7, 1912. I note also that he speaks of the operations having been substantially continuous. On the other hand, you have testified that your so-called experimental machine was used intermittently for probably between one and two months from about the 1st of August, 1911. Please supplement your testimony by such explanation as will clear up this apparent inconsistency.

A. The experimental machine was hastily installed in crowded quarters and was run during a period in which many changes

1441 were being made in the mill. Because of mechanical difficulties requiring shut-downs for repair and the very frequent shut-downs of the mill, thereby shutting off the supply of feed for the test machine, its work was intermittent rather than truly continuous. Its use was altogether abandoned after it had been demonstrated that the process evolved by me at Basin could probably be successfully used.

X Q. 117. I still do not understand how Mr. Gibson could have charge of the flotation plant, directing its operations, until the middle of February, 1912. Please explain this.

A. After the experimental machine was abandoned, another machine was made use of in the mill.

X Q. 118. Was this before or after October 9, 1911, when the present suit was commenced?

By Mr. Kremer: Objected to as incompetent, irrelevant and immaterial, and having no bearing upon the issues of this case, the issue in the case being what was done by defendant at the time specified in the bill of complaint, and not subsequent thereto; and for the further reason that no patentable process has been disclosed by the complainant, and consequently there could be no basis for a claim of infringement.

By Mr. Williams: In view of the fact that the question is carefully limited to what took place before the commencement of this suit, under the charge of infringement in paragraph sixth of the bill of complaint, which covers all that was done "before the
1442 commencement of this suit," it is submitted that the question calls for evidence relevant, possibly competent, and material.

A. It is my memory that the second machine referred to was thrown into service on or about the 13th or 14th of October. I have no definite record at hand and may be mistaken as to this date.

X Q. 119. I take it, therefore, that this machine was either in course of construction or completed on October 9, 1911, when this suit was commenced?

A. My memory is that it was in course of construction on that date.

X Q. 120. Is that machine in existence today?

By Mr. Kremer: Objected to for the same reasons in the objections to X Q. 118.

A. I believe it is.

X Q. 121. When your witness Gibson testified, he stated that at one time additional oil or acid was put into the concentrates after they left the rougher and went to the cleaner, but he could not remember whether this was true on August 10, 1911, when Mr. Nutter saw the plant in operation. Will you clear up this uncertainty, if possible?

A. It is impossible for me to do so, as I have no recollection bearing upon the matter.

X Q. 122. I now show you Hoover patent No. 953,746, patented April 5, 1910, and call your attention to a deflector shown in the drawings and marked K. Do you understand this drawing,
1443 and if so, did you have in your experimental machine any part which performed the function of deflecting or guiding upward the material which flowed from the agitation box to the spitzkasten?

By Mr. Kremer: Objected to for the reason that it is incompetent, irrelevant and immaterial, and has no bearing upon the issues of the case, in that, in the pending suit, the question of apparatus is not in issue.

A. Reading through the text of the whole patent, to get an ex-

planation of the part of the cut to which you refer, I find that several of the claims refer to the use of an inclined guide-plate, in one case referring to it as an inclined adjustable guide-plate. The apparatus used by me, which has been referred to as the experimental machine, did not contain any inclined guide-plate. In front of the opening through which the material agitated in the agitating cells passed into the overflow settling box was placed a submerged trough with horizontal bottom and vertical sides; the top of the front side of this was submerged under 3 or 4 inches of water. The function of this submerged trough was to break the flow of the material and prevent a rapid surface current being directed over the discharge lip.

X Q. 123. I take it that the broken lines shown in "Defendant's Exhibit Sketch of the Experimental Machine" in each instance alongside of the letters V or V', etc., are intended to represent a plan view of the vertical wall of the trough to which you refer?

1444 A. Yes, and the same might well be indicated by the initials C. R. B., current retarding box.

X Q. 124. You have described an hydraulic elevator used at two places in your experimental machine. In the use of this hydraulic elevator, was there a constant or substantially constant head maintained, and if so, to what extent?

A. The term "hydraulic elevator" is used in the same sense in which it is used in placer mining, and refers to a jet of water being introduced into a pipe in such a way as to force the contents of the pipe to move in the direction of flow of the current of water which is introduced under pressure. It is my recollection that the pressure water was kept flowing constantly in sufficient volume to cause a continual flow of material. The pressure on the pipe from which the water was drawn was presumably constant, as it is my understanding that the pipe was supplied by water from an elevated ditch or flume, which always contained water.

X Q. 125. About what was the area of the jet opening of this hydraulic elevator?

A. My memory is that the delivery pipe was one-half inch in diameter. I do not remember definitely as to whether the nozzle end of this pipe was drawn to a small aperture or not.

X Q. 126. When, to your best recollection, did you first see the patent to T. J. Hoover, No. 953,746, which I have shown you, or a copy thereof?

A. To the best of my recollection, the first time I ever saw a copy of the patent which you have shown me was during the spring

1445 of 1911, when I received a number of patents relating to flotation processes from the U. S. Patent Office.

X Q. 127. I now show you a copy of patent No. 979,857, to T. J. Hoover, patented December 27, 1910, and ask you when you first saw this patent, or a copy thereof?

By Mr. Kremer: Objected to as wholly incompetent, irrelevant and immaterial, and in no way bearing upon the issues of this case, it being specifically shown by the patent submitted to the witness that the invention relates to improvements in apparatus for ore con-

centration, and does not relate to any process, and the issue in this case is that of a process, and does not bear upon apparatus.

A. The answer to this question is the same as the answer to the previous question.

X Q. 128. You have said that you and T. J. Hoover designed the slide machine. What was your individual contribution to the design of that machine?

A. My recollection is that after having discussed many possible modes of introducing a sheet of metal or hard rubber or something of that sort through a side opening in a vertical agitating box in such a way as to divide the machine into an upper and a lower part after pulp had been agitated in it, so as to allow the top water and floating concentrates to be drawn off through an opening in the side
1446 of the machine above the inserted horizontal partition, Mr. Hoover suggested that it should be possible to divide a machine into an upper and a lower portion and slide off the upper portion over a proper guide, as was finally done in the machine which we evolved. We discussed the matter together, making several sketches, details of each being contributed by each of us, and finally upon the form which was finally constructed. Such computations as to size as were necessary were made by me.

The machine as originally designed was constructed under my supervision, was tested by me, and was modified under my supervision in a number of minor features, after the first tests were made.

X Q. 129. By whom was the machine constructed?

A. My memory is that it was constructed by a Mr. Dearden, a model-maker and machinist in London.

X Q. 130. Did you, after the termination of your employment by Minerals Separation, Limited, or about that time, endeavor to obtain from this same model-maker a duplicate of this machine for your own use?

A. I discussed the matter with him, explaining that I wished the machine for my own personal use, and obtained from him the figure which he would have to charge for it, if he was to make one for me. He asked me if I thought Minerals Separation would have any objection to his furnishing me with the machine, and I told him that I did not know, but that it was possible that they would. The figure that he asked for one was entirely prohibitive, and I dropped the matter, knowing that whenever I wanted one I could have one
1447 made for me at a cheaper price. As the machine was unpatented and was designed by myself and Mr. Hoover, I could see no impropriety in attempting to get one made, and naturally went to the man who had previously made one for me.

X Q. 131. It is not quite clear from your testimony whether or not you saw the testing machine in the London plant of Minerals Separation, Limited, in operation. Please answer as to this.

A. In answer to a previous question I have stated that I saw in operation in the London plant a special test machine devised by Mr. Nutter, and which I understood was not successful. I have no definite memory of having seen any other large test machine working

in the London plant. I am of the belief that I did not, and am strengthened in this belief by the definite memory that Mr. Howard, who was foreman at the test works, had promised to write out for me a complete statement with directions as to how to proceed to carry on a working test, and that such statement had not been presented to me when I decided that I should not contract with the company for another year, and that at the time when I called in Mr. Williams, the company's secretary, and turned over to him all papers belonging to the company which were in my possession, which was a week or more before I left the company's service, I addressed and forwarded to Mr. Howard a letter stating that as I was not to continue to work with the company I would request him not to forward to me the statement which he had in preparation. If I had been
1448 familiar with the details of the methods used in carrying on large tests in the London works, there would have been no occasion for him to prepare such a statement.

X Q. 132. Mr. Nutter, in his answer to X Q. 51, has described the testing plant at the London works. You saw this plant, did you not?

A. It is not my memory that I ever saw the testing plant in London, which consisted of eight mixers. My memory is that the machine which I saw there had six mixers, with five spitzkastens attached, the first mixer only having no spitzkasten attached to it. I have no definite memory as to the details of valves, piping and mixers of the machine seen in London, nor any record containing this information.

X Q. 133. What is the extent of your actual knowledge as to the tests of the ore of the San Francisco Del Oro mine, which you witnessed in South Wales?

A. My only personal knowledge on the subject is that I observed that a very scanty and thin froth or film of concentrates was on the surface of the spitzkasten, and that the tailings showed the presence of a considerable amount of sulfid minerals.

X Q. 134. How long did you observe this process in operation at this place?

A. My memory is that on two succeeding days I was present in the Emu works in South Wales, where this test was going on, for perhaps half an hour at a time on a number of occasions on each day. As the work was so apparently unsuccessful, I would go out
1449 and walk about and return to see if the oeprators were meeting with greater success. The appearance described was typical of that witnessed on all the occasions upon which I remember to have been present in the plant. The attendants were constantly making changes, in hopes of achieving better results.

Cross-examination closed.

Redirect examination.

By Mr. Scott:

R. D. Q. 135. What, if you know, was the material that was being

terated in the experimental machine at Basin, at the time Mr. Nutter entered the plant?

A. At that time the machine was running upon the accumulated low-grade concentrates which had been produced upon the vanners. This was one of those numerous occasions which have previously been referred to upon which the main body of the mill was shut down, and the ordinary feed was not available for the experimental machine.

R. D. Q. 136. Have you found that any particular temperature is necessary in the flotation process as you have practised it?

A. I have found that with the only oil which we have used, the Perry product, which comes to us in a solid form, that it is difficult to obtain the best results, when the temperature of the pulp being treated is much below 25° Centigrade. Above 25° Centigrade and at that temperature, it is possible, by the process which I have worked out, to get higher results than, to my knowledge, have ever been obtained elsewhere.

1450 R. D. Q. 137. To what do you attribute the difficulties in operating at a lower temperature than 25° Centigrade?

A. As I have observed that if the oil used is brought into a fluid condition by heat and then dropped upon the surface of mill-water which has not been heated, and which through a great part of the year is very nearly at the freezing point, that it will solidify at once, I am convinced that the reason that it is difficult to obtain the best results below the temperature indicated, is because the oil becomes solidified before it has been finely divided and brought into contact with the sulfid particles, which it is desired to float.

R. D. Q. 138. In your operations with the experimental machine at Basin, did you add powdered ore to water or acidified water as one of the steps of the process?

A. I did not. The ore treated was never in a powdered condition, and the water in which the ore was crushed was not acidified before coming into contact with the ore.

R. D. Q. 139. At how early a date, as near as you remember, did you first know that zinc ores were being commercially worked in the Butte district?

A. It has been well known for years past, that zinc ores or zinc-bearing ores, occurred in the Butte district. I have no definite memory as to when I first knew that an attempt was being made in the Butte district to produce and market zinc ores or concentrates, but I am certain that I knew of it before the first examination of

1451 the Butte & Superior Copper Company's property was made by Mr. Kuehn, as I knew that H. C. Hoover was interested in investigating some zinc business at Butte.

Redirect examination closed.

Recross-examination.

By Mr. Williams:

R. X. Q. 140. I take it that in your answer to R. D. Q. 138 you have interpreted the word "powdered" as meaning both finely ground and dry. This is true, is it not?

A. That is my understanding of the meaning of the term, and is the definition which I have found given to it in one or more dictionaries consulted.

R. X. Q. 141. Do you suggest that the temperature of 25° centigrade which you have given is the critical temperature below which no substantial results are obtainable in the process as carried on by you in Basin, Montana?

A. I have seen a very considerable recovery made at 20 or 21° Centigrade, if I remember correctly, but at that temperature the appearance of the tailings would indicate that the results being obtained were not the best of which the machine and process were capable.

R. X Q. 142. And haven't you found that better results are attainable at 30° Centigrade than at 25° Centigrade?

A. I have seen the whole appearance of the machine and the tailings indicate as good results when the temperature was 25° Centigrade as at any other temperature. As a matter of safety,
1452 the temperature is usually kept a few degrees higher than that.

Recross-examination closed.

Re-redirect examination.

By Mr. Scott:

R. D. Q. 143. At the time of the receipt of the letter from Mr. John Ballot, to which you have referred, in which letter reference is made to Butte, Montana, were you aware of the existence of zinc-sulfid ores at that place, and of the fact that they were being worked?

A. I was.

Deposition closed.

JAMES M. HYDE.

Adjourned until Wednesday, May 1, 1912, at 10 A. M., same place.

Met pursuant to adjournment. Present counsel as before.

EUGENE A. BYRNES, a witness produced in behalf of defendant, having been duly cautioned and sworn, testifies as follows:

Direct examination.

By Mr. Scott:

Q. 1. Please state your name, age, residence and occupation.

A. Eugene A. Byrnes; 50 years; residence, Washington, D. C.; occupation, metallurgical and chemical engineer.

Q. 2. Please state your education and experience in your profession.

1453 A. I am a graduate of the University of Michigan and Columbia University, having received therefrom the degrees of Bachelor of Arts, Master of Laws, and Doctor of Philosophy. After graduating from the University of Michigan I taught physics for a short time. I then entered the examining corps of the United States Patent Office and remained there some seventeen years, having been for ten years principal Examiner of the Division of Metallurgy and Electrochemistry, also having charge of the laboratory. Resigning in November, 1901, I engaged in private practice, and am now a member of the firm of Byrnes, Townsend & Brickenstein, with offices at 918 F street, N. W., Washington, D. C. I am a member of various scientific bodies, including the American Chemical Society, the American Electrochemical Society and the Society of Chemical Industry. As Principal Examiner in the Patent Office, it was my duty to determine the novelty and patentability of inventions relating to the treatment of ores and the recovery of metals. I had to do with a great many applications involving the recovery of floating minerals and the recovery of minerals by flotation, including the well known Potter and Delprat methods of flotation, involving the use of a chemically-generated gas. In my own practice, I have also had much to do with the separation of minerals and their recovery by flotation, including improvements on the Potter and Delprat methods and methods involving the separation of sulfids by aeration, such as the Macquisten method, which I assisted in operating and practically demonstrating. I have visited many of the prin-

1454 cipal mining sections in the West, and am familiar with the apparatus used in mining and metallurgy. I have frequently testified in patent suits relating to metallurgical subjects, both for individuals, corporations and the U. S. Government, including the recovery of zinc. I maintain a chemical laboratory in the City of Washington, and am principally occupied in investigating the novelty of and giving opinions and testimony relative to chemical inventions and patents therefor. I am an associate editor of the Journal "Metallurgical and Chemical Engineering."

Q. 3. The bill of complaint in this suit charges infringement of United States patent No. 835,120, granted to H. L. Sulman, H. F. Kirkpatrick-Picard & J. Ballot, Nov. 6, 1906. Are you familiar with the contents of this patent and the art to which it relates?

A. Yes.

Q. 7. Will you explain your understanding of the patent referred to, making reference in your answer, if necessary, to such matters connected with the prior art as you may desire?

A. This patent relates to the concentration of ores, and to the recovery or separation therefrom of the portion containing the valuable constituent, whether metal or graphite, leaving the gangue or portion containing rock and of no value.

The alleged improvement is one in that old class of methods employing an oil, fatty acid or the like to coat the valuable constituents of the ore, which may be called "mineral," for short,
1455 leaving the non-valuable constituents, gangue or tailings uncoated, although they become wetted with water.

The three patentees, alleged joint inventors, in the beginning of the description of the patent, refer to the prior U. S. patents Nos. 777,273 and 777,274, granted to A. E. Cattermole, as patents describing general processes of separating metalliferous matters from ore by the use of oil or oleic acid, a fatty acid, calling attention to the fact that this prior inventor used an amount of oil varying from 4 to 6 per cent. of the weight of metalliferous matter present. They then announced the discovery constituting the novel feature, improvement or principle upon which their patent is based, in the following language:

"We have found that if the proportion of oily substance be considerably reduced—say to a fraction of one per cent. on the ore—granulation ceases to take place, and after vigorous agitation there is a tendency for a part of the oil-coated metalliferous matter to rise to the surface of the pulp in the form of a froth or scum."

They next announce a number of factors or conditions which assist this small amount of oil in coating the metalliferous matter and forming a froth, to-wit:

(1) A slight acidification of the water in which the oiling is effected, that is, the water in which the finely-divided metalliferous matter is in suspension as a pulp, as by the addition of up to one per cent. of sulfuric acid, or other mineral acid or acid salt.
1456 This acidification is said to increase the selective action or preferential affinity of the oily substance for the metalliferous matter, and to prevent it from coating the gangue. The patentees call attention to the fact that the addition of acid is not intended to generate a gas to float the mineral, and state that: "the proportion of acid used is insufficient to cause chemical action on the metalliferous mineral present."

(2) Warming of the pulp, or mixture of water and suspended ore, to which the oily substance has been added, is stated to increase the tendency for the oil to disseminate through the pulp, and the rapidity with which the metalliferous matter becomes coated with oil.

(3) Fine pulverization of the ore is said to assist the formation of froth, and "slime material," that is, the mineral in impalpable small particles floating in the pulp, is said to most readily generate scum, larger particles being floated with more difficulty.

(4) The amount of mineral recovered by flotation of the froth is said to vary with different ores; and

(5) The recovery also varies with different oily substances, necessitating a preliminary test to determine which is most suitable for the particular ore.

The patent then proceeds with a detailed description of the treatment of a particular ore, containing ferruginous blende, zinc
1457 sulfid carrying iron; galena, lead sulfid; and gangue consisting of quartz, rhodonite and garnet, silica or silicates containing no metalliferous values. The sequence of operations is as follows:

The ore is finely powdered.

The powdered ore is mixed with water containing up to 1 per cent. of a mineral acid or acid salt, specifically sulfuric acid or ferric sulfate.

A very small proportion of oleic acid, say from 0.02 to 0.5 per cent. on the weight of the ore, is added.

The mixture of powdered ore, water, mineral acid or acid salt, and oleic acid is warmed, say to 30° to 40° Centigrade.

The warmed mixture is briskly agitated in a mixer or the like, for example the cone mixer shown in the specified prior patents to Cattermole, for a period of from two and one-half to ten minutes, until the oleic acid has been brought into efficient contact with all the mineral particles, that is, until they have become coated with this oily agent.

Agitation is discontinued, whereupon a large proportion of the mineral present is said to rise to the surface in the form of a froth or scum, consisting of air-bubbles introduced into the mass by agitation, adhering to the oiled mineral particles only, the unoiled gangue particles, without adhering air-bubbles, not floating.

The froth is now removed "by spitzkast, upcast, skimming, draining, or otherwise," and may be treated with alkali to remove the oleic acid. If the ore has been crushed to 90 mesh to the inch, from 70 to 80 per cent. of the metalliferous matter in the ore is said to be recovered in this first froth.

1458 To recover the metalliferous matter remaining in the tailings, especially including the larger particles, various flotation methods may be used, for example:

The pulp freed from the froth and containing the gangue and non-floated mineral may be aerated by distributing it as a thin layer on a shaking table, air jets being also blown upon it, and the aerated mineral may be floated off and separated from the gangue, which sinks. Reference is here made to a specific process of this character which is described in another United States patent granted to the same inventors, No. 879,985.

An alternative method for the treatment of the tailings consists in placing the pulp containing the tailings and mineral unrecovered in the first froth in a closed vessel and compressing air or gas therein, thereby causing an excess of air to be dissolved in the pulp; and then releasing the pressure and allowing the dissolved air or gas to be evolved in bubbles throughout the mass, these bubbles attaching

themselves to the (oiled) metalliferous matter and raising it to the surface as a second froth. This method is referred to as the subject-matter of another application, which has matured into patent 835,479, to the same inventors.

The drawings of the patent illustrate apparatus which may be employed. The agitator for effecting the preliminary oiling of the mineral is illustrated in Figure 1, being a cone agitator of the
1459 kind previously employed by Cattermole, and shown in his patent 777,273, consisting of a vertical cylindrical vessel in which is centrally journaled a vertical shaft carrying a hollow cone near its lower end. A hopper C and belt-conveyor D carry the crushed ore into the top of the vessel, and a swan-neck pipe H, controlled by a cock G, delivers the froth from the vessel. A pipe F having a cock F′, serves to deliver the oleic acid or other oil, in regulated amounts, into the agitator, corresponding to similar devices shown in the Cattermole patent. The patentees state that several of these agitators may be used, connected in series, as shown in said Cattermole patent, Figure 2 of the drawing illustrates the same agitator, not showing the ore-feeding mechanism.

Figure 1 also illustrates the apparatus used for separating the oiled and aerated metalliferous froth from the water and tailings, consisting of three funnel-shaped chambers, of progressively increasing size, having quadrangular tops arranged in series, these chambers or "boxes" being filled with water and receiving the oiled and agitated pulp delivered from the cone mixer through pipe H, first flowing onto a smooth slightly-inclined plane or flat trough O, which delivers into the smallest chamber or box. The heavier sands and coarser mineral sink in the first box, the medium sands and any residual mineral in the middle box, and the fine sands in the last box. A jet of water may be led into the bottom of each chamber, to assist the separation, as usual in devices of the type termed "spitz-
1460 kasten." The metalliferous froth floats on over the top of each chamber and is discharged from the edge of the last chamber into a launder P, delivering to a filter. The water separated from the metalliferous matter is pumped back to the cone agitator, and may pass through a heater in transit. Any mineral, oiled, but not floated, depositing with the gangue in the chambers J^2 or J^3, may be recovered by the method of compressing a gas into the pulp and then releasing the pressure to evolve the gas and aerate and float the oiled mineral of the froth, as heretofore described.

In the modified apparatus shown in Figure 2 of the drawing, the oiled and agitated pulp from the cone mixer is passed through a discharge-conduit a', pipe a^2, pump e and pipe e', into a closed chamber f, wherein it is first subjected to an atmosphere of air or other gas compressed to from 50 to 100 pounds per square inch, for a few minutes, being thence discharged to the froth-separator with three chambers heretofore described. The air or gas dissolved under pressure and evolved upon discharge from the compression-vessel, assisting the aeration produced in the cone agitator, is said to cause all of the oiled mineral to rise to the surface as a single froth, obviating the necessity of retreating the tailings, as with the first apparatus illustrated.

The patentees state that an amount of oleic acid constituting 0.1 per cent. of the ore has been found suitable and economical for effecting the flotation, but that smaller amounts may be used. They also state that the oleic acid may be liberated in the pulp, instead of directly added thereto, by first introducing a dilute soap
1461 solution and then adding a mineral acid to decompose the soap, referring to the Cattermole patent 777,274 for a description of this procedure. They note that oleic or other fatty acid, coating the mineral, may react with soluble salts of lime, iron, etc., present to form insoluble soap adhering to the mineral and capable of attaching it to bubbles of air and floating it, like the fatty acid itself.

Claims 1, 2, 3, 4, 5, 6, 7, 8, 12 and 13 of the patent in suit are limited to the use of a proportion of an oily liquid having a preferential affinity for metalliferous matter amounting to a fraction of one per cent. on the ore, specifically to the use of oleic acid in amounts from 0.02 to 0.5 per cent., claims 8 and 13 requiring that oleic acid shall be produced in the mass with decomposition of a soap solution.

Claims 9, 10, 11 specify "a small quantity of oil."

Each claim includes the step of agitating the mixture to effect the oiling of the mineral and formation of the froth.

Claims 2, 3, 4, 6, 7, 8, 11 and 12 specify the use of slightly-acidified water, or water containing a fraction of one per cent. of sulfuric acid, claim 11 requiring that the amount shall be insufficient to cause chemical action.

Claims 3, 4, 7, 8, 10, and 13 include the step of warming the mixture.

Claim 13 includes the particular mode of separating the froth by passing the oil and agitated pulp on the surface of a current of water over columns of water, as by the use of the spitzkasten illustrated.

Q. 5. Please compare the subject-matter of patent 835,120,
1462 which you have been discussing, with the prior art as you understand it, stating what, if anything, of novelty you find in that patent.

A. I will first refer to a number of prior U. S. patents, considering them chronologically, to-wit:

No. 345,951, granted July 20, 1886, to Hezekiah Bradford. I quote from this patent as follows:

"Almost all metallic ores—coal and other substances—when pulverized, contain a greater or less proportion of particles of ore or metal that will, even if pulverized in water, float on the surface of the water, and the finer the substances are pulverized the greater the proportion of floating particles. These floating particles appear to possess some peculiar quality which repels the water from their surfaces, especially when such particles are exposed, even momentarily to atmospheric air, and when such exposure takes place the water is repelled from a sufficient portion of their surfaces to cause such particles to float off on the surface of the waste water from the other particles that sink in the water.

"In concentrating ores they should be pulverized fine enough to liberate the metallic particles and the particles of native metals from their gangue. * * *"

"the floating particles will pass, with a part of the waste water, over the overflow I of tank D into a receptacle, L, in tank M, with a fall sufficient to plunge the floating particles under water. This
1463 receptacle L should be small enough so that the whole surface of the water therein will be constantly acted upon by the plunging water, in order to thoroughly wet the floating particles, some of which will rise many times to the top of the water before they get wet enough to sink; * * * they will not float again without exposure to atmospheric air. * * *"

"the substances must be conducted to trough R, from which these substances must be raised by an elevator, R′, high enough to be deposited in the trough or incline b^2, which will deliver them upon the belt E, a portion of which is immersed in water in tank D, and the upward motion of this belt will elevate these tailings and floating materials out of the water, so that atmospheric air will come in contact with the tailings. When the belt delivers these substances again to the water, the tailings will immediately sink in the water to the bottom of the tank D, while the particles that repel the water will float and pass off. * * *"

This patent describes and utilizes the well known fact that finely-divided minerals, although having a weight or specific gravity much greater than that of water, will nevertheless float on the surface of water, provided they are dry or only slightly wetted, or if wetted, are re-aerated by lifting them out of the water into the atmosphere, whereby they become coated with a film of absorbed air. Such particles float on the water by reason of the well known capillary phenomenon called "surface tension," the upper surface of
1464 the water acting like a thin, elastic membrane, and being slightly depressed by each air-coated particle, not coming in actual contact with it, but depressing the surface of the water beneath it until it displaces an amount of water equal in weight to that of the particle. So, films of dust float on water, although consisting of individual particles of rock much heavier than water. Another familiar illustration of this phenomenon is the fact that a sewing needle, although having a specific weight about eight times that of water, will nevertheless float on water if the surface of the needle be coated with a slight imperceptible film of oil or grease.

No. 348,157, granted August 24, 1886, to Carrie J. Everson. I quote from this patent as follows:

"The discovery which forms the basis of my invention is that metals and metallic substances in a comminuted state will unite with compounds of fats or oils and acids, and that such compounds will not unite with comminuted quartz or other rocky gangue. The essential feature of the method which constitutes my invention, therefore, consists in commingling with pulverized ore a fat or an oil, either animal, mineral, or vegetable, or a fatty constituent or

acid of an animal or vegetable fat or oil, or any constituent of a mineral oil, together with an acid either mineral or vegetable, or a soluble neutral or acid salt, for the purpose of effecting a union of the free metal or metallic portion of the ore with such admixed material, whereby the same may be retained in the subse-
1465 quent separation of the quartz or other rock therefrom by washing or other suitable means. * * *"

"In putting my invention into practice any fat or oil, and any acid, either mineral or vegetable, or any soluble neutral or acid salt, or any compound of fats and oils with appropriate acids, may probably be successfully employed, at least such is the case with all of these agents with which I have so far experimented. I have used petroleum and one of its several constituents—namely, paraffine-oils—also tallow, (melted,) lard, lard-oil, red-oil, (impure oleic acid,) cotton-seed oil, castor-oil, sperm-oil, and linseed-oil, and some combinations of these with each other. The acids which I have employed are sulphuric, hydrochloric, nitric, phosphoric, acetic, oxalic, tannic, and gallic. I have also used the following salts, to-wit: the sulphates and chlorides of sodium, zinc, and copper, and the double sulphate of potash and alumina. The selection of the appropriate agents will, however, be largely determined in the practical working of my invention by the consideration of economy, which will obviously exclude the greater number of those above enumerated. * * *"

"Take an ore assaying twelve ounces per ton in silver and containing forty-eight per cent. silica, 6.3 per cent. zinc, 1.5 per cent. copper, fifteen per cent. iron and aluminum, 6.5 per cent. lead, 14.18 per cent. sulphur, 7.19 per cent. arsenic. Of this ore take four (4) ounces by weight in pulverulent form, prepare a
1466 mixture containing sulphuric acid, cotton-seed oil, and water, in all about twelve fluid drams, of which ten drams are of water and about two drams are acid and oil in the proportions of fifteen parts of the oil and two parts of the acid by measure. In making this fluid mixture the acid and oil are first mixed with each other, the acid being added to the oil very gradually, so that the temperature will not rise above 120° Fahrenheit. The stirring in of the acid should be thorough, as it tends at first to gravitate to the bottom. After a few hours, in a summer temperature, the mixture will be ready for use, and, preferably, in such a temperature, should not be prepared long before using, though if it should have stood long enough to solidify it should be gently heated before adding the water thereto. In winter or in air-tight vessels it may be kept for a number of weeks or even longer, and then rendered fit for mixing with water by heating gently when required for use. The water may be advantageously added in installments of about three equal parts, and the mixture stirred for each addition of water until it stiffens. After stirring in the entire quantity of water the compound is added to the ore, the proportions of ore and compound being chosen with a view to producing a stiff mass after the materials have been incorporated, such proportions being therefore variable in different cases with this end in view. The stirring or incorpora-

tion of the ore with the liquid should of course be thorough
1467 for the purpose of bringing the mineral into contact with the oil and acid as completely as possible, and after such incorporation the mass is then in condition for the washing out of the quartz by the action of water which will be applied to the mass in sufficient quantities for this purpose. * * *"

"When petroleum or a constituent thereof is used the oil should desirably be first mixed with the ore, then water added containing a suitable amount of free acid or a soluble neutral or acid salt, the quantity of water being ample for the washing-out operation, which is to follow, and the quantity of acid sufficient to cut the sand away from the otherwise cohering mass. In the case of petroleum or its constituent, paraffine-oil, one or two fluid drams of acid to one gallon of water is sufficient for this purpose. The petroleum which I have used was 30° Baume; and I have found three fluid drams of oil abundant for properly moistening two ounces of heavy ore, or in the ratio of about a barrel of oil to the ton of ore, the amount being, of course, variable with the relative bulkiness of the ore.

"In the use of petroleum, or of a liquid constituent thereof, like paraffine-oil, the condition of the concentrated mass is more liquid than when a vegetable or an animal oil or a fatty constituent thereof is used, and a somewhat different means or method should be employed for removing the sand. In practice, the concentrate, after thorough agitation of the mass and detachment of the sand, will in this case be preferably removed by means of a constant over-
1468 flow of water from a washing-out vessel, by which overflow the concentrate will be floated off. Devices and methods now well known in wet separation of ores will be suited to this part of the operation, bearing in mind that the sand and mineral are merely transposed or their relative positions are reversed, because the sand is heavier than the mixture of mineral, oil, and acid. A proper selection of devices for this purpose will be apparent to those skilled in the wet separation of ores. * * *"

"The proportions in which the acids or salts are added to the oils or fats may vary according to the kind of acid or oil employed, and also according to the kind of ore to be treated; and the manipulation of the substances employed may be varied from that above set forth in either formula given. These matters may be determined in individual cases by the operator; and I do not, therefore, restrict myself to any particular proportions of the substances employed, though I have above indicated proportions of certain acids and oils by one of the other of which practical results may be obtained upon almost all varieties of ores.

"It is also not essential to my invention that the acid or salt employed with a vegetable oil be added to the oil before the incorporation of the oil with the ore, as it is entirely practicable, at least in most, and possibly in all, cases, to first mix such oil with the
1469 ore and thereafter add the acid, as set forth in the use of petroleum."

Adjourned until Thursday, May 2, 1912, at 10 A. M., same place.

May 2, 1912.

Met pursuant to adjournment. Present, counsel as before.

Direct examination of Eugene A. Byrnes continued.

(Answer to Q. 4 continued:)

This patent thus announces several facts of great interest and pertinence, to-wit, that—

(1) Any fat or oil, including red-oil or impure oleic acid, cotton-seed oil, or petroleum and its constituents, has a selective action or preferential affinity for comminuted metals and metallic substances admixed with comminuted quartz or other rocky gangue;

(2) A mineral or vegetable acid, or a soluble neutral or acid salt, such as sulfuric acid or a sulfate, tends to effect a union of the metallic portion of the ore with the admixed fat or oil, and to enable it to be retained thereby during the separation of the gangue, the use of both the fat or oil and the mineral or vegetable acid or salt being specified as the essential feature of the method;

(3) The material used for oiling the mineral should be
1470 sufficiently liquid to enable it to be thoroughly brought in contact with the mineral, and in winter, when it has become solidified, it should be heated to melt and thin it, although in summer temperature such heating may not be necessary. Some of the oils or fats prescribed are solid at ordinary atmospheric temperatures, for example, tallow, which the applicant notes should be used melted. The red-oil, or impure oleic acid, mentioned, ordinarily produced from tallow in separating the stearin and other harder fats used for candle-making, etc., may be either solid or liquid, depending on the season of the year, whether winter or summer. Other oils mentioned, cotton-seed, castor, sperm, linseed, and petroleum, are liquid at ordinary atmospheric temperatures;

(4) The proportions of oil or fat and acid used must vary according to the kind of each employed and according to the kind of ore to be treated, and must be determined in individual cases by the operator;

(5) "The operation of concentration as a whole, or in its practical form as applied to the separation of rocky mineral ores, involves the reduction of the quartz or other rock containing the mineral to a powder."

That is, fine comminution is necessary to liberate the mineral from the gangue, or produce separate particles of each, enabling the mineral to be preferentially coated with the oily material;

1471 (6) Thorough agitation of the mass or pulp comprising water, the finely divided ore, the oil or fat, and the acid, is necessary, the purpose being to bring the mineral into contact with the oil and acid as completely as possible to enable each particle of mineral to be preferentially oiled. The particular apparatus to be used is not described or illustrated, the statement being made that proper devices can be selected by those skilled in the art;

(7) When the mixture of pulp, oil and acid is sufficiently liquid,

as when using a naturally liquid oil like petroleum or paraffin-oil, the mass is first thoroughly agitated and the concentrate will then be separated from the sand or gangue by flotation, "by means of a constant overflow of water from a washing-out vessel, by which overflow the concentrate will be floated off" * * * "because the sand is heavier than the mixture of mineral, oil, and acid." As the patentee states that devices and methods of this character are well known in the wet separation of ores, reference is evidently here made to the use of the common spitzkasten, in which a constant current of water lifts the lighter material which floats off, while the heavier portions gravitate to the bottom against the current.

No. 466,753, granted January 5, 1892, to Edgar A. Hockley. I quote from this patent as follows:

"My invention relates to a novel form and construction of mech-
anism for treating ores, and is designed to save the float min-
1472 eral, usually called 'slimes' and sometimes termed 'flour'
gold and silver * * * In all classes of ore there is more or less of this light flour or float mineral which is held in suspension by the water, while in some kinds of ore this class of mineral amounts to a very large proportion of the value, which is therefore ordinarily lost or carried to the dump with the so-called 'tailings.'"

"The principle of the invention is to aid or increase the natural floating tendency or buoyant condition of the mineral particles, whereby the valuable portion is made to float, while the gangue, which is heavier, settles, thus effecting the separation. * * *" "air, water, steam, etc., may be forced into tubes 16 and thence into the bottom of the tank for the purpose of agitation, whereby the light mineral is washed or separated from the heavier gangue and an increased upward or buoyant tendency given said mineral, keeping the same upon the surface of the water until discharged into the filtering tank. * * * At the bottom of the discharge end or side of the tank is located the lower trough 19 for carrying away the gangue which settles in the bottom of the tank and the upper trough 20, into which the float mineral passes, which collects in the form of a scum upon the surface of the water."

The patentee, in referring to flour gold and silver as "light," does
not mean that the specific gravity of gold and silver, or the
1473 mineral to be recovered, is less than that of the gangue, but
to the fact that it tends to float upon the water by reason of the surface-tension phenomenon heretofore referred to by me, due to the fact that the very small particles of metal or mineral are surrounded by a film which prevents them from being wetted. The patentee proposes to increase the natural floating tendency of the mineral by the use of injected streams of air, etc. Such streams of air would tend to aerate the mineral, or attach more air to its particles, as films or bubbles, enabling it to float as a scum, which moves through a conduit to a filtering-tank.

No. 469,599, granted February 23, 1892, to Albion M. Rouse. I quote from this patent as follows:

"My invention relates to an improved method and apparatus for

removing or separating slime or fines from water carrying ores; * * *"

"As the slime-water passes slowly through the chamber 21 it is acted upon by an innumerable number of air-bubbles escaping from the perforate pipes 26, 27, into which the air is forced through pipe 25. The constant upward circulation of air through the slime-water tends to elevate all foreign matter to the surface of the water and to create or form a mass of strong foam having a great carrying energy for matter foreign to water. As the foam accumulates in the chamber 21 it is forced out through the passage 23 to a drier."

No. 676,679, granted June 18, 1901, to Francis E. Elmore.

1474 This patent corresponds to British patent 21,948, dated October 18, 1898, upon which suit was brought in England by The British Ore Concentration Syndicate, Limited, and another against Minerals Separation, Limited, the plaintiff in the present suit. I quote from this U. S. patent as follows:

"My invention relates to a method of separating metallic constituents of ore from rocky and other impurities, which is distinguished from the usual amalgamation processes in which the ore forms an amalgam with mercury.

"It consists in mixing the crushed ore with water and mixing with the ore and water a substance other than mercury which has the power of causing the metallic portions of the ore only to adhere to it, while the water and rock or other impurities of the ore remain unaffected and may be drawn off. The metallic constituents of the ore are then recovered from the substance in which they are entrapped. I have found that the heavier oils are efficacious for this purpose and particularly that kind of oil known as the 'residuum' of mineral oil after the more volatile elements have been distilled off.

"In carrying out my process I prefer to mix the ore with water—as, for instance, by the wet crushing method in common use—using a sufficient quantity of water to make a freely-flowing mixture, the fineness of the ore depending upon the particular kind of ore treated.

1475 I then place the ore and water in a suitable vessel, add a quantity of the oil depending upon the particular kind of ore under treatment, and then agitate the mixture without breaking up the oil into small globules. The metallic particles will adhere to the oil and be buoyed up and floated by it, while the other constituents of the ore will remain in the water. The water and attendant impurities are then drawn off, leaving the oil and metallic particles. The metallic particles are easily separated from the oil by mechanical or other means. * * *"

"The lowest layer is drawn away as tailings, which may be again treated with oil by leading them by a pipe *f* to a second drum *g*, where they are again mixed with oil supplied by a pipe *h*, the mixture being discharged into a second subsidence vessel *k*. This may be again repeated until little or none of the metallic constituents remain in the tailings. * * *"

This process is based on the selective action or preferential affinity of oil for mineral rather than gangue, the oiled metallic particles floated up by the oil, while the tailings subside. The process provides

for retreatment of the tailings by the same process of oiling and flotation, to recover any mineral which may not have been floated in the first operation.

No. 689,070, granted December 17, 1901, to Alexander S. Elmore. This patent corresponds to British No. 6,519, dated March 28, 1901,
which was also involved in the British suit brought against
1476 the present plaintiff. I quote from this U. S. patent as follows:

"The selective action of oil has been utilized for separating metallic substances from earthy or rocky constituents of ores. This has generally been done by pulverizing the ore and suspending it in a considerable quantity of water, so as to make a freely-flowing pulp, then mingling with it oil, preferably heavy oil, such as is obtained from petroleum after some of the lighter oils have been distilled from it. When the mixture rests, the oil, with most of the metallic substances entrapped in it, floats at the top and is separated from the rocky or earthy matters, which are run off with the water as tailings. The oil is afterward separated from the metallic substances, usually by centrifugal action. In carrying on this separating process I have discovered that in some cases a slight acidulation of the mixture greatly enhances the selective action of the oil, so that metallic substances, as well as other mineral substances, such as sulfur and plumbago, can be separated from the earthy matters with which they are naturally associated better than when there is no acid present. By this means some metallic substances can be separated from others—such, for instance, as sulfids from oxids. The acidulation may be effected either by adding a little acid to the oil, in which case an acid that will dissolve in or mix readily with the oil, but which is insoluble, or nearly so, in water—as, for instance, oleic
acid—is to be preferred, or the acid may be added to the
1477 aqueous pulp, in which case sulfuric acid may be employed or the acid cuprous liquors obtained in mine working. The quantity of acid added in either case is small, as it often need not exceed one five-hundredth part of the volume of oil or water employed in the operation. The quantity of acid required to produce the best result varies, according to the character of the material treated, and I therefore do not confine myself to any definite proportion. * * *"

"In applying my invention to the separation of metallic and earthy or rocky ingredients of ore I prefer to mix with the powdered ore from five to ten times its weight of water, forming a thin freely-flowing pulp, which I allow to flow into the mixer A through a pipe D. Into this mixer I also admit a thin stream of oil from a pipe E, provided with a regulating valve, and a small quantity of acid from a pipe Q, also provided with a regulating-valve. The oil and acid are mixed with the pulp by the rotating beater C. The oil by its selective action coats or absorbs the metallic particles, sulfids, the tellurids, and the like. If plumbago, elementary sulfur, or other substances of like character are present, the oil attaches itself to or coats such particles, while it does not coat or attach itself to the rocky or earthy particles present."

This patent thus refers to the selective action or preferential affinity of oil for the metallic substances rather than the earthy
1478 or rocky constituents of ores, and to the fact that a slight amount of acid greatly enhances this selective action. Both a mineral acid, sulfuric, and a fatty organic acid, oleic, are mentioned as suitable. The amount of acid to be used is small and is varied to suit the material treated and give the best result. Both the oil and acid are fed to the machine for mixing them with the orepulp by a regulating valve, enabling the amount to be suited to the conditions as determined by practical work.

No. 735,071, granted August 4, 1903, to Guillaume D. Delprat. I quote from this patent as follows:

Title: "Extraction of Zinc, Lead, and Silver Sulfids from their Ores."

"This invention relates to the extraction or concentration of sulfid ores to separate them from their gangue.

"The ore is first finely ground or stamped and then immersed or dropped into a bath or solution, hereinafter described. An apparatus for carrying out the process forms the subject-matter of a separate application, filed March 9, 1903, Serial No. 146,895. This process is readily carried out at ordinary temperatures and depends upon the ore particles being attacked by the acid to form a gas. Each ore particle so attacked will have a bubble or bubbles of gas adhering to it, by means of which it will be floated and can be skimmed or floated off the solution. The particles of the gangue, such as silicates
1479 and other substances not quickly or readily attacked by acid or dilute acid, fall to the bottom of the body of the solution and are removed from time to time. * * *"

"Under the bottom 4 is a piping 14, forming, with the air-inlet cock 15, a Bunsen burner for gas, so that the solution or liquor may be heated, if desired. The ore fed from the hopper 1 drops into the bath and slides by gravity over the bottom to the sump, the ore particles being raised to the surface of the liquor by the gas-bubbles formed, the action of the acid on these ore particles during their travel along the inclined bottom and ore floated off with the overflow through the trough 13, if desired, skimmed off."

No. 736,381, granted August 18, 1903, to Moritz F. R. Glogner. I quote from this patent as follows:

"* * * The mixture containing only fine earthy substances and graphite is mixed with a quantity of water the weight of which is about three or four times as great as that of the graphite mixture. Petroleum is then added in the approximate proportion of one part petroleum to two parts graphite contained in the mixture. Now the whole is given a strong rotating, rocking, or reciprocating movement within a closed vessel, so that the mixture is thoroughly stirred and intimately mingled. The petroleum is broken up into very fine drops or perles, and every graphite particle when touching them is attracted, while the earthy particles, which were already satu-
1480 rated with water before the addition of petroleum, remain completely neutral. After the vessel has been allowed to stand the earthy parts sink down, while the petroleum carrying the

graphite tends to rise to the surface. After a certain time water is then sprinkled over the surface of the liquid by means of a rose or the like, whereby the fine earthy particles are caused to sink more quickly, and any earthy particles which may be carried upward by the rising petroleum and froth are caused to sink down again.

"The vessel is shaken once, twice, or repeatedly after the graphite has been skimmed, and every time some petroleum is added. The whole of the graphite will then be taken off by the petroleum. * * *"

Apparatus is illustrated and described for carrying out the process, comprising a number of agitators.

"Each agitator A is obliquely suspended on three chains B in such a manner that the wave formed when the vessel is agitated falls back on the higher part of the bottom and a thorough mixing of oil and graphite is obtained, the operation being at the same time facilitated. Each vessel A has a handle C. * * *"

Graphite, to the separation of which this patent is directed, is one of the minerals the recovery of which is contemplated by the patent in suit. The Glogner process relies on the preferential affinity of petroleum for graphite rather than rock and gangue, and
1481 directs that the mixture of water, ore and petroleum, shall be given a strong agitation, as by rotating, rocking or reciprocating it, thereby causing every graphite particle to be coated with the petroleum. Such strong agitation is well designed not only to intimately distribute the petroleum in very fine drops throughout the pulp, but also to aerate the pulp and cause the oiled mineral to float to the top as a froth. The waves formed by reciprocating the agitating vessels in short shocks would naturally entrain and intermingle with the pulp a large amount of air in the form of bubbles, just as an ocean wave entangles air and forms a floating froth or foam. Agitation by "a strong rotating * * * movement," as suggested, is the type of agitation employed in the patent in suit to form a froth.

No. 745,960, granted December 1, 1903, to Israel F. Good. I quote from this patent as follows:

"The object of the invention is in a ready, simple, rapid, thoroughly-feasible, and practical manner initially to separate pure graphite from any associated impurities and conserve it and then to effect saving of the bulk of whatever remains in the impurities separated out. * * *"

"In the hopper the material has oil, either coal-oil or any other suitable kind, sprayed upon it from a pipe 27 and the mixed graphite, sand, &c., escapes through a chute 28 into a washing-tank 29, containing a rotary agitator 30, driven by a belt 31, from the upper shaft 32 of the conveyor 22, the water of the tank 29
1482 being kept at boiling heat by steam supplied through pipes 32a. The lighter particles of graphite separated by the agitator and that float on the surface of the water in the washing-tank are removed by a skimming device 33 and are discharged into a tank 34, containing water, whence they are removed."

No. 777,273, granted December 13, 1904, to Arthur E. Cattermole.

This is one of the patents referred to in the patent in suit. I quote therefrom as follows:

"The present invention relates to improvements in the separation of the metalliferous constituents of ores and the like from gangue by means of the selective action of oils and certain tar products or similar compounds (all hereinafter referred to as 'oil') or metallic or metalliferous matter.

"The invention depends upon the application of the following facts: First, when a mixture of powdered metalliferous matter and gangue is treated with oil suspended in water—that is to say, in emulsion—the oil has a more or less selective action and will coat the particles of metalliferous matter in preference to the particles of gangue, while the particles of gangue will be wetted by the water; second, if the water which is mixed with the oil is acidulated with mineral, fatty, or other acid the selective action of the oil will thereby be rendered more marked and decisive; third, if the proportion
1483 of oil is kept within reasonably low limits (differing in different cases, according to the nature of the mineral to be treated and the consistency and nature of the oil) and if the mixture of water, oil, metalliferous particles, and gangue be thoroughly agitated the metalliferous particles which have become coated with oil will adhere together and form granules, which granules, partly by reason of gravity or partly on account of their bulk, as compared with the individual grains of gangue, will offer ready means for separation in an up-current separator, a jig, or other similar appliance. This action is facilitated if the oil before addition to the liquor is brought into the condition of an emulsion in water containing a small percentage of soap or other emulsifying agent. These facts are utilized for the purpose of separating the metalliferous constituents from the gangue of the ore in the following manner: In a suitable apparatus, an example of which will be hereinafter described, the ground or pulped ore is caused to be violently agitated, as by a revolving stirrer, in a mixture of water and oil, the liquor being acid. As the agitation proceeds the particles of metalliferous matter agglomerate together and may be observed in the form of granules, the size of which will depend, among other things, upon the percentage of oil used. * * *"

"A series of connected mixing vessels A' A^2 A^3 A^4 A^5 A^6 are provided with stirrers B, rotated from driving shafts B'. Crushed
1484 ore from a hopper C and water from a tank D are introduced into the first vessel, A', and oil or emulsion is fed from a tank E, through pipes E' E^2 E^3, to the various vessels. The mixture is vigorously agitated to break up and emulsify the oil and to bring about intimate contact of the divided oil with the metalliferous mineral particles and of the oiled particles with each other. It is found under these conditions the metalliferous mineral particles abstract the oil and become coated with a thin oily film, which is insufficient to materially lessen their specific gravity, and that under agitation such slightly-oiled particles adhere, nucleate, and agglomerate into small more or less rounded masses or granules disseminated throughout the mass of gangue, which remains free and practically devoid of oil.

In order to maintain the liquid mass in which the separation is effected in an acid condition, a small proportion of the sulphuric or other acid is introduced into one or more of the vessels from a tank F, having discharge-pipes F^3 F^4 F^5 F^6. * * *"

"The proportion of oil used depends upon its viscosity, the fineness of the ore and other factors, and the consistency and size of the mineral granules desired. The more oil used the larger, softer, and less numerous the granules. With, say, ten per cent. of oil to the weight of metalliferous mineral a few pasty masses of oil-agglomerated metalliferous mineral matter will generally result. Oil in
1485 excess of this may cause all the granules to coalesce into one soft mass. Usually the amount of oil varying from four per cent. to six per cent. of the weight of metalliferous mineral matter present in the ore yields granules of suitable size, consistency, and specific gravity for ready separation from the gangue in the upcurrent or other apparatus used for classification. * * *"

"The 'oil' used may be animal, vegetable, or mineral oil or mixtures of these or such coal or wood tar products or other substances which exercise, like oils, a preferential physical affinity for metallic mineral matter as distinguished from gangue. * * *"

"It has been found that if the water in which the operation is conducted contains a percentage of acid varying in the case of sulfuric acid of 1.84 specific gravity from one-half of one per cent. to a tenth of one per cent., the operation is greatly facilitated. Indeed, if there is no acid present there is a great tendency for the oil to coat the gangue or some portion of the gangue, as well as the metalliferous particles. It is preferable to use water acidulated with about one-fifth of one per cent. of this acid, and it is found in practice that such a degree of acidulation is sufficient completely to prevent the gangue from being oiled, while it is not, generally speaking, enough to cause the water to act chemically upon the metalliferous matter.

"I am aware that the selective action of oils and the like
1486 on metallic matter has been made the basis of previous processes for separating the metalliferous constitutents of ores from gangue. For example, oil has been used to float off metalliferous mineral from ore-pulp, and its use has also been proposed to form a pasty mass of crushed ore from which the gangue could afterward be washed out by means of water, and I do not claim the employment of oil in any such manner. * * *"

Summarized, this patent disclaims as old, but utilizes the selective action of oils for the metalliferous constituents of ores. It describes, but does not claim as new, the use of acid, such as sulfuric acid, to increase the selective action of the oil and prevent it from coating the gangue. It notes that a small amount of acid, for example, a fraction of 1 per cent. on the amount of water in the pulp, is sufficient. It directs violent agitation of the mixture of pulp, oil and acid, and illustrates for this purpose a series of connected vessels each containing a revolving cone, the precise type of agitator adopted in the patent in suit. The percentage of oil specified is based on the weight of the metalliferous minerals that are present in the ore and not on

the ore itself. Apparatus of the spitzkasten type is used to separate the lighter from the heavier material, after agitation with oil and acid, and the bulk of the water is returned for reuse in the process.

Adjourned until Friday, May 3, 1912, at 10 A. M., same place.

1487 May 3, 1912.

Met pursuant to adjournment. Present, counsel as before.

Direct examination of Eugene A. Byrnes continued:

Answer to Q. 4 continued:

No. 776,145, granted November 29, 1904, to Charles V. Potter. I quote from this patent as follows:

"The object of my invention is to separate metals from sulfid ores by an expeditious, effective, and inexpensive means and method.

"The crude ore, concentrates, tailings, or slimes after being pulverized are placed in a suitable vat or vessel and a solution is then added, such solution consisting of water with the addition of from one per cent. to ten per cent. of any acid (preferably sulfuric acid, for reasons hereinafter stated), the acidulated strength of the solution being determined by the quality or nature of the sulfid ore to be treated. The small quantity of acid added does not act as a solvent.

"Ores containing lead, zinc, copper, iron, gold, and silver in combination with sulfur I treat as follows: The ore in a state of fine division is placed in a vat or such like vessel provided with an internal stirrer or stirrers. The acidulated solution is then added thereto, such solution containing in the first instance, say, one per cent. only of the acid when mixing it with the ores, and after
1488 heat is applied thereto, as hereinafter directed, gradually increasing its acidulated strength until the determinate strength is reached, which in most instances will amount to two and a half per cent. of acid, or thereabout, to be decided on or governed by the apparent action of the solution on the material under treatment. Heat being applied, the effect of the acidulated solution becomes apparent by the bubbling up and gathering on the surface of the fluid of the metallic concentrates in the form of a pasty mass. Should this pasty substance be scanty, thin, and not swell and accumulate rapidly, so as to overflow the vat if not skimmed off, more acid must be added until the maximum separative activity is reached, which very slight experience and observation in applying this treatment to sulfid ores will enable the operator to determine. * * *

"The stirrers are then freely used, and heat is applied to the vat or vessel directly or by means of steam injection therein at or near the floor of the vat or vessel. As the temperature of the solution and other contents of the vat or vessel rises it causes the metals to rise upward from the bottom of the vat and float upon the surface, from which it may be allowed to flow automatically and continuously into a separate receptacle or be skimmed off, as arranged, into a separate vessel for further treatment. The gangue accumulating

in the bottom of the separating-vat, containing a small proportion of gold and silver, as well as all the rhodonite, garnets, silica. * * *

The process of this patent is similar to that of the Delprat
1489 patent, No. 735,071, heretofore referred to by me, except that the pasty mass containing the metallic concentrates which is removed by overflow or skimming, is formed by the action of sulfuric acid, stirrers, which "are freely used," and heat, which may be that of steam injected into the agitating vessel at or near its bottom. The agitating vessel illustrated in the drawing and described, consisting of a vertical shaft carrying four radial stirrer arms at its lower end and rotated by gears at the upper end, is practically identical with that used by the defendant in this suit and shown by him in his recent U. S. process patent No. 1,022,085, dated April 2, 1912. The free use of an agitator of this type causes the solution to become thoroughly aerated and impregnated with fine air-bubbles which would assist the gas chemically generated by Potter in forming a pasty floating mass carrying the concentrates. Potter indicates that the effect of the applied heat is to increase the generation of gas by the action of the acid on the ore.

No. 777,274, granted December 13, 1904, No. 788,247, granted April 25, 1905, to Arthur E. Cattermole, Henry L. Sulman and Hugh F. Kirkpatrick-Picard. The first of these patents is referred to in the patent in suit as describing the optional method of liberating the oleic acid used for oiling the mineral "in situ in the pulp by decomposing a dilute soap solution with mineral acid." The applications for these two patents were filed simultaneously, and the description of the method of oiling the mineral by a fatty acid,
1490 etc., liberated from a soap solution added to the pulp is almost identical in both, lines 10 to 56 of page 1 of the first patent being nearly the same as lines 9-53 of page 1 of the second. The first patent then describes separation of the oiled mineral from the gangue by the use of the process claimed in the Cattermole patent 777,273, heretofore considered by me, that is, by causing the coated metalliferous particles to adhere together and form granules or small agglomerated masses, which are separated from the gangue in an up-current device, the metalliferous granules settling while the gangue is carried upward. The claims of this first patent cover the oiling of the mineral by an organic or fatty acid liberated from soap, followed by separation of the oiled mineral by agglomeration.

The description of the second of these two patents, following line 53 of page 1, is more general as to the mode of separating the oiled mineral particles from the gangue. I quote therefrom as follows:

"* * * The mineral particles now attached to or more or less coated or inclosed by films of fatty or resin acids and the like are capable of being separated from the gangue or earthy particles by various methods dependent upon this altered physical condition. For example, the coated mineral particles may be removed by generating gaseous bubbles in the mixture which preferentially attach themselves to the fatty or similar acid-coated particles and raise them to the surface of the pulp, whence they may be removed by

1491 skimming or the like. If the ore contains a carbonate, any small excess of the acid used to decompose the soap or similar alkaline compound will also liberate bubbles of carbonic acid, which will attach themselves to the fatty acid-coated mineral particles and float them to the surface, or a suitable carbonate (or other substance capable of liberating a gas on the addition of a suitable acid, such as an easily decomposable sulfid, &c.) may be initially added to the ore mass for such purpose, or the mineral particles may be caused to adhere to metallic or other suitable surfaces coated with similar fatty acids, or, finally, the coated mineral particles may be caused to adhere to wood, sawdust, or other suitable material lighter than water coated with similar fatty acids, &c., which can then be removed by flotation, in each case leaving the mineral-free gangue particles capable of rejection. * * *"

The first two claims of this second patent cover the process of oiling the mineral by an organic acid liberated from a soap solution, followed by separation of the coated material from the non-coated gangue in any manner whatever. The remaining claims, 3 and 4, cover the same mode of oiling the mineral, followed by the separation of the oiled mineral by gas-flotation. The language of claim 3 as to this feature is as follows:

"bringing the liquor into intimate contact with a gas which will adhere to the coated particles and separating out the coated mineral matter which floats."

1492 The flotation of the oiled mineral by "generating gaseous bubbles in the mixture," that is, by bubbles of carbonic acid liberated from an ore containing a carbonate by the action of an acid, was well known prior to the filing date of this second patent, having been described in British No. 12,778 of June 4, 1902, to Alcide Froment. The liberation of a gas by the action of an acid on a sulfid in the ore was also well known, being characteristic of the prior Potter and Delprat methods, to which I have referred. The flotation of mineral particles by causing them to adhere to wood, sawdust, etc., had also been described in U. S. patent 471,174, granted March 22, 1892, to Charles B. Hebron and Carrie J. Everson. Reference was doubtless intended by the matter quoted from this second patent 788,247 to these prior methods, well known to those skilled in the art.

No. 793,808, granted July 4, 1905, to Henry L. Sulman and Hugh F. Kirkpatrick-Picard, on an application filed October 5, 1903. I quote from this patent as follows:

"The present invention relates to the concentration of ores by separation of the metalliferous constituents and graphite, carbon, sulfur, and the like from the gangue by means of oils, grease, tar, or any similar substance which has a preferential affinity for metalliferous matter over gangue.

"According to this invention we utilize the power which is possessed by films or bubbles of air or other gas of attaching themselves to solid particles moistened by oil or the like.

1493 "According to one method of carrying out our invention suitably-crushed ore is suspended in water. To this sus-

pension a proportion of oil, grease, or tar (hereinafter referred to as 'oil'), is added and duly mixed with the mass by any suitable means in quantity insufficient to raise the oiled mineral by virtue of the flotation power of the oil alone. A suitable gas is now generated in or introduced into the mixture, such as air, carbonic-acid gas, sulfuretted hydrogen, or the like. For example, bicarbonates or carbonates, either soluble or insoluble in water (preferably the latter) or easily-decomposable sulfids and the like may be used with acid solution. In such cases, if desired, the addition of acid may be made to the mixture after the addition of the gas-producing reagent. In the case of solutions containing free alkali the addition of acid sufficient to neutralize this must be made before the gas is produced. If desirable, gaseous bubbles may be produced by electrolytic methods or by means of various other known reactions.

"According to another method of carrying out this invention the oil is not added alone but the pulp is submitted to the action of a current of air or other gas bubbles, the air or other gas being first suitably charged either with the vapor of a volatile oil, such as petroleum of low boiling-point, or with the spray of any other suitable volatile or non-volatile or fixed oil or the like. The oil may be sprayed or reduced to a state of such fine division that minute
1494 globules of the same can remain temporarily suspended in an air or other gas current by the use of any suitable spraying or atomizing device and the air-current introduced into the ore-pulp, preferably at the bottom, by means of a pipe or pipes provided with suitable perforations or by other suitable contrivance. The minute oil globules or the condensed vapors or volatile oils attach themselves to the metalliferous particles in preference to the gangue.

"The oiled metalliferous particles resulting from either of the processes above described have the power of attaching to themselves with a greater comparative strength than the gangue particles the films or bubbles of gas phich exist in the mass and are thus raised to the surface of the liquor by gaseous flotation. They can then be removed by skimming or other suitable means. The gangue particles unwetted by oil or grease are not floated up with the oiled mineral particles, and thus in the main remain at the bottom of the vessel containing the mixture. The oil can then be removed from the oiled mineral by any suitable known means.

"In the case in which oil-spray is used the temperature of the mass of pulp may be varied to secure the best results with spray of oils of varying viscosity. Instead of suspending the oil-spray in an air-supply system suitably-devised atomizing-jets operated by air or a jet of steam and air may be introduced directly into the pulp. The gas used may be other than air, such as carbonic acid, steam,
1495 or mixture of these. We have also found that a particle of metalliferous mineral if coated with a minute film of oil, grease, or the like then exposed to air will not readily sink in water. It is therefore unnecessary in some instances to employ gaseous bubbles to effect flotation. For example, according to an alternative method for effecting the separation of metalliferous matter from gangue the metalliferous ore-pulp is intimately mixed in any suitable

matter with a small proportion of oil and then sprayed in as finely divided a state as necessary through air by means of jets, revolving disks, or otherwise, and the sprayed product is then allowed to fall upon the surface of water. The gangue particles wetted only with water at once sink, while the metalliferous particles coated with a thin film of oil and after exposure to air float on the surface of the water and may be removed by skimming or other suitable means."

Three forms of apparatus are illustrated for carrying out the process, according to some of the various modifications thereof which have been described:

Figure 1 shows an apparatus comprising a long tank having an inclined bottom, just above which is supported a coiled perforated pipe, journaled at its ends in bearings in the end-walls of the tank. The ore-pulp is fed into the shallow end of the tank, and a mixture of air and oil, that is, compressed air carrying a spray or vapor
1496 of oil, is forced into one end of the coiled pipe and thence through its numerous perforations into the pulp in the tank. This apparatus is well adapted to preferentially coat the metalliferous constituents of the ore with a minute film of oil insufficient to itself raise the mineral, and also to attach to the oiled mineral particles films or bubbles of air to float them as a froth, which is then discharged over the top of the end-wall of the tank into a launder, the uncoiled gangue remaining at the bottom of the tank whence it may be withdrawn through a tap. The coiled perforated pipe will also act as an efficient agitator to entangle and intermingle a considerable amount of atmospheric air with the pulp, assisting the aeration. The patentees note that different oils may be used of varying viscosity, and provide for varying the temperature of the pulp to secure the best results, it being obvious that an oil which is thick or solid at ordinary temperatures would necessitate heating of the mass to render it sufficiently fluid to coat the mineral particles with a minute film of oil sufficient to cause them to adhere to films or bubbles of air or gas.

Figure 2 of this patent illustrates another apparatus in which oil is first mixed with pulp and the aeration of the oiled mineral particles to form the froth of concentrate is effected by passing the mixture of pulp and oil through an ejecter supplied with compressed air. The oiled and aerated pulp is then delivered onto a froth-separator consisting of a series of funnel-shaped vessels of progressively increasing size, like those employed in the patent in
1497 suit, the metalliferous froth floating onward over the upper edge of the vessel into a launder, and the gangue, classified in different sizes, settling in the several vessels and thence being discharged through taps at the bottom.

Figure 3 illustrates an apparatus in which oil is first mixed with the pulp, and the aeration to form the metalliferous froth is effected by flowing the mixture in a thin layer over a revolving disk, the oiled and aerated pulp being thence discharged into a concentric series of annular V-shaped troughs, the froth flowing outward to a discharge launder and the gangue settling to the bottom of the troughs and being thence discharged.

The patentees refer to the known method of chemically generating a gas to float the oiled particles, by the action of acid on carbonates or sulfids, as practiced by Froment, Potter and Delprat; also to the evolution of gaseous bubbles by electrolytic methods, that is, by the decomposition of a portion of the liquid into its gaseous elements by the passage of an electric current through it.

This patent to Sulman and Kirkpatrick-Picard, two of the three alleged joint inventors of the patent in suit, as well as number 788,247 heretofore discussed, granted jointly to Sulman, Kirkpatrick-Picard and Cattermole, clearly discloses the following facts:

(1) The preferential affinity of oils, fats and the like for mineral particles rather than gangue.

(2) The preferential affinity of the oiled mineral particles for films or bubbles of gas, however supplied to the pulp.

1498 (3) The flotation and removal of the oiled and aerated metalliferous particles as a froth.

(4) The addition of acid to a pulp of ore containing carbonates or sulfids capable of reacting with the acid.

No. 793,808 provides for varying the temperature of the mixture of the mass of pulp, dependent on the viscosity of the oil used; it also illustrates in Figure 1 an apparatus employing an efficient agitator, and in Figure 2 the precise froth-separator of the patent in suit, except for the up-currents of water in the spitzkasten commonly used.

No. 807,501, No. 807,503, granted December 19, 1905, to Alfred Schwarz.

I quote from the first of these patents as follows:

"In the concentration of ores by the employment of hydrocarbons as adhesive agents it has been observed that sulfids yield better results than oxids, carbonates, and chlorids. In fact, so far as known to me, a practical application of such process before my inventions relating to this art has been largely, if not wholly, confined to sulfid ores. * * *"

"Of hydrocarbons which are solid at normal temperatures and required to be melted there may be used paraffin or ozocerite, or a resinous hydrocarbon, such as resin, pitch, or asphaltum. Of normally liquid hydrocarbons there may be used any suitable

1499 vegetable, animal, or mineral oil. These hydrocarbons may be used singly or in combination of two or more, it being understood that the constitution of the adhesive agent will depend upon the character of the ore to be treated, varying as the ore varies.

"Ore either in a dry or wet condition is mixed in any suitable vessel having an agitator with the hydrocarbon, sufficient quantity being added to effect the desired separation. If the hydrocarbon is one which is solid at normal temperatures, it is first melted and then stirred in with the ore, the mixture being effected by any suitable mechanical means and, if desired, air, steam, or gas may be injected into the mass either alone or to assist the mechanical agitation. The injection of such gaseous agent results in the hydrocarbon taking up an appreciable quantity of air or gas, giving a certain sponginess which increases its floating power.

"As a specific example of my invention I have used as an adhesive agent a mixture of paraffin and resin, heat being employed if necessary to maintain this compound in a melted condition after it has been mixed with the ore.

"After an intimate mixture with all parts of the ore has been effected the mass is subjected to the action of water heated to any desired temperature, even as high as the boiling-point, whereby the earthy or rocky constituents are liberated and washed out and
1500 settle in the bottom of the vessel. The metallic constituents of the ore having united with the adhesive agent may be skimmed or screened off and run to a centrifugal drier for the separation or recovery of the concentrates from the adhesive agent. * * *"

I also quote from the second of these patents as follows:

"Heretofore the separation of the values in ores has been effected by mixing the pulverized ore with a product resulting from the distillation of petroleum, the ore having been previously mixed with sufficient water to form a freely-flowing pulp. The oil in such method exercises the property of attaching itself to and buoying up the metallic constituents of the ore that are suspended in the pulp; but it has little or no effect upon the earthy constituents. I have found that the efficiency of the selective action of oils generally, either mineral, vegetable, or animal, is increased by the addition thereto of a fatty matter which is solid at normal temperatures, as paraffin, stearin, or palmitin.

"In carrying out my invention I proceed as follows: The ore is first crushed and screened to a convenient size for working and is then thoroughly and intimately mixed with the selective material, which in this instance is a compound of mineral, vegetable, or animal oil and a fatty matter of the character above specified,
1501 such mixture being solid at normal temperatures. Such material may be readily prepared by dissolving the fatty matter in the oil medium, heat being employed to melt the fatty matter, if necessary, and to maintain the compound in a liquid condition during its incorporation with the pulverized ore. As a specific example of a selective material I prefer crude petroleum or any of its products, to which is added about nine to ten per cent., by weight, of paraffin, such proportion having been found to give good results with a copper-sulfid ore.

"Any suitable apparatus may be employed to effect the mixture of the ore and selective material, all that is essential being a vessel provided with agitating-blades. In such vessel the ore is mixed with sufficient of the selective material to make a thick pasty mass, the agitation being continued long enough to bring the selective material into intimate contact with all portions of the ore. The vessel may be steam-jacketed or otherwise suitably heated if found necessary to maintain the selective material in a liquid condition. After a complete incorporation of the selective material with the ore water, preferably under pressure, is injected into the mass by suitably-arranged pipes and agitation continued until the water is distributed throughout the mass. The mass is then allowed to subside, when the selective material, with the entrapped metallic

1502 constituents of the ore, will rise to the top and may be removed in any suitable manner, as by floating over the top of the vessel. The values may be separated from the selective material in any suitable or well-known manner—as, for example, by a centrifugal drum or filter-press. The tailings, being unaffected by the selective material, will remain in the water and settle to the bottom of the vessel, from which they may be drawn off and, if necessary, subjected to further treatment for the recovery of any values they may contain.

"In the concentration of ores by the selective action of the compound above described the action is facilitated and better results secured by the injection of a gaseous fluid—such as air, steam, or gas as carbon-dioxid gas—into the mass. This may be done by suitably-arranged pipes leading into the bottom or sides of the vessel, the effect of such use of air, steam, or gas being to break up and subdivide the mass in a complete and thorough manner. Furthermore, it results in the selective material taking up an appreciable quantity of air or gas, giving a certain amount of sponginess, which increases its floating power. * * *

"1 designates a bin or hopper from which the pulverized ore is discharged into a vessel 2, which is preferably steam-jacketed and provided with an agitator 3. In this vessel the ore and selective agent are intimately mixed, and from said vessel the mass is discharged into a vessel 4, provided with an agitator in which

1503 it is treated with water slightly acidulated, if desired, to effect the separation of the selective agent, with the entrapped metallic constituents, from the tailings. If cold water is employed, the selective agent will be solidified and rising to the top is conducted by a trough 5 to a remelting and storage vessel 6. If heated or boiling water is employed in the vessel 4, the selective agent will be maintained in its liquid condition and as it rises with the entrapped metallic constituents is run by the trough 5 into the storage vessel 6 and from the latter to a centrifugal-drum 7 for the separation of the values from said agent. The recovered agent is collected in a storage vessel 8, from which it may be raised to the mixing vessel 2 by a pump 9. The separating vessel 4 is provided with suitable pipes 10 for the admission of air, steam, or gas and with a pipe 11 by which the tailings may be discharged into a vessel 12. * * *"

These patents disclose the following points:

(1) The selective action of oil generally, mineral, vegetable or animal, for the metalliferous constituents of ore, especially sulfid ores.

(2) The use for oiling the mineral of an oil containing a fatty matter which is solid at normal temperatures, such as stearin; and of a mixture of an oil, which may be animal oil, and a fatty matter, which may be stearin, which is solid at normal temperatures.

1504 "Red-oil," the commercial form of impure oleic acid produced by the candle and soap-maker, is a mixture of this character, containing stearic and palmitic compounds, and being entirely solid at the lower range of atmospheric temperatures.

(3) The use of a sufficient quantity of the oil or oily mixture to

effect the desired separation, that is, the oiling and floating of the metalliferous constituents.

(4) The use of slightly acidulated water to prevent the adhesion of the oil or oily mixture to the gangue or tailings, that is, to increase its selective action or preferential affinity for the mineral.

(5) The thorough mechanical agitation of the ore with the oily material and with the acidulated water, as by agitating blades, in open vessels, which agitation will not only thoroughly distribute the oil throughout the ore and cause it to coat the mineral particles, but will also entangle the atmospheric air and thoroughly aerate the mixture to produce a floating froth of concentrates.

(6) Further aeration of the mixture by the injection of streams of air, steam or carbon dioxide gas, giving the froth sponginess and increased floating power, thus floating some of the oiled min-
1505 eral which might otherwise remain in the tailings and necessitate their re-aeration in a subsequent operation.

(7) The heating of the mass, as by steam-jacketing the agitator vessel, or using heated or boiling water, to maintain the oiling agent in a liquid condition.

(8) The flotation of the aerated and spongy mass of the selective material, or oiling agent, with the entrapped metallic constituents of the ore, and its delivery to a centrifugal filter, the tailings being settled out and withdrawn at the bottom.

(9) The retreatment of the tailings, if necessary, for the recovery of any values therein contained.

No. 809,959, granted January 16, 1906, to Edmund B. Kirby, on application filed December 14, 1903. I quote from this patent as follows:

"The invention relates to the concentration of ores. It may be employed to separate the metallic minerals from the gangue, or to separate certain of the metallic minerals from others or from others and the gangue.

"The operation of the process is dependent upon the fact that, because of differences in physical characteristics of the various constituents of mineral material, such constituents show preferences of adhesion between two commingled, but immiscible liquids. * * *
1506 "The process, as an entirety, in its best form for use with Rossland ores for the purpose stated consists in the following steps:

"First, in thoroughly agitating together (*a*) the pulverized ore or mineral material, (*b*) enough water to make with said pulverized ore a flowing pulp, and (*c*) a solution of bitumen in a thin distillable hydrocarbon liquid as kerosene, these materials to be so thoroughly agitated together as to finely subdivide said solution into small globules and bring said globules into contact with substantially all of the pulverized mineral particles which will, by preference, adhere to them.

"Second, in allowing the hydrocarbon-coated particles to float to the surface of the mass, and in rendering this separation substantially complete by gently agitating the mass, and by injecting gas into the same, and preferably also discharging into the mass fine streams of

the solution. When the separation is completed, the floating hydrocarbon-coated concentrate is removed for subsequent treatment.

"Third, in filtering said concentrate to free it so far as possible from the hydrocarbon liquid.

"Fourth, in distilling said coated concentrate and condensing the hydrocarbon vapor to be used again.

"It is thought that the use of a gas to assist in the flotation of the coated particles, as set forth in the description of the second
1507 step of the process, is radically new in this art, irrespective of its association with the other steps described. It is that which makes it possible for the first time to use thin oils and hydrocarbon. * * *

"The employment of the gas in the manner stated brings in a more powerful floating agency than anything before used, which results in the recovery of this floured oil together with numerous coated particles which would not otherwise be floated. This step of the process is therefore useful with any and all liquids lighter than water which exhibit preference of adhesion for the metallic mineral particles. Kerosene alone, for example, may be used with most ores to take out the sulfids provided the gas is used, as stated, to cause the flotation of the kerosene-coated particles. * * *

"Preferably the pulverized ore is mixed with three to five times as much water, by weight, and to this is added a sufficient amount of the kerosene-bitumen solution, excellent results being obtained by using one-fourth to three-fourths as much, by weight, as ore. The preference of the solution for some of the mineral particles may be regulated by altering or varying the quantity of the solute substance and by varying the temperature at which the solution is used. The preference of the water for other mineral particles may be regulated by adding some acid or other chemical. * * *

1508 "The injection of a gas, preferably air, into the mass, which is the chief novel characteristic of the second step of the process, assists in the flotation of the hydrocarbon-coated particles. This makes it possible to finely subdivide the solution by the agitation, and this greatly increases the chance that all of the mineral particles which exhibit preferential adhesion for it shall be brought into contact with it. Some of the hydrocarbon-coated particles will float to the surface without assistance; but a considerable quantity of such particles will not be sufficiently buoyant, and some of such particles and some globules of the mixture would be trapped in the sands. In order to recover this less buoyant material together with the globules of the mixture, the mass which tends to settle is slowly lifted and turned over to liberate the coated particles and the globules, and at the same time a gas, preferably air, is blown into the mass preferably near the bottom thereof. The air-bubbles not only tend to attach themselves directly to the coated particles, and thus float them to the surface, but the air becomes dissolved in the water to its maximum capacity. This dissolved air tends to again separate itself from the water and attach itself in minute globules to the coated particles. I find that air, carbon dioxid, hydrogen, and marsh-gas are satisfactory

for this purpose, and doubtless many other or all gases will
1509 operate in the same way, but I prefer air. * * *"

Adjourned until Monday, May 6, 1912, at 10 A. M., same place.

Washington, D. C., May 6, 1912.

Met pursuant to adjournment. Present, counsel as before.

Direct examination of Eugene A. Byrnes continued:

Answer to Q. 4 continued:

Complete apparatus is illustrated for carrying out the process, comprising an open vessel A termed a "mixing-tank." In this tank is centrally journaled a vertical shaft *a*, to the lower end of which are attached four radial arms having agitating blades. A reservoir M having a valved outlet is provided to hold the oil or oily solution and deliver the proper regulated amount into the tank. In use, the "shaft *a* is to be rotated rapidly, and the result is a thorough commingling of the various parts of the charge," that is, of the pulp of water and ore, the oil, and the acid which may be used to assist the preferential affinity of the oil, the temperature being varied to also regulate the preference. The thoroughly agitated and commingled mixture is then delivered from tank A into an open vessel B termed a "separating tank." A vertical central shaft having four radial
arms with stirring blades is also journaled in this tank. The
1510 arms are here provided with small depending pipes for delivering streams of air and oil into the mixture. Upon rotation of the shaft and the injection of more oil with streams of air, some of the metalliferous particles which had not been sufficiently oiled and aerated to float in the first mixing-tank, but which remain trapped in the sands or gangue, will be rendered buoyant and will float. It is noted that not only will the streams of injected air form bubbles directly attaching themselves to the oiled particles, but that some air will become dissolved in the water and again separate in minute globules attached to the oiled particles. Kirby states that the first tank A may be omitted, its function being then performed in the second tank B. For this purpose, the agitator in tank B is rapidly rotated to thoroughly mix the (acidified) ore-pulp with the oil, and to oil and aerate the mineral. The agitator is then rotated slowly, with injection of air, etc., whereupon the oiled and aerated mineral rises to the top and floats as a froth. The slow agitation of the mass at this time liberates buoyant particles mechanically held therein. The froth of concentrates is now directed by a curved skimming bar 38 into a settling and washing chamber or box 29 arranged near the top and at one side of the tank B. This settling device comprises a series of funnel-shaped compartments, of progressively increasing size, of the spitzkasten type, the last of these
compartments having a pipe 35 to deliver an up-current of
1511 water therein and a gate 32 to deliver the froth to a launder.

Tailings are discharged from openings at the bottom of the compartments, falling down to the bottom of the tank B. The froth

or concentrate is delivered to filtering apparatus, and the filtered concentrates may be heated to distill off and recover the oil, the use of a thin distillable oil being one of the features described and claimed as novel.

No. 838,626, granted December 18, 1906, to Edmund B. Kirby, on application filed December 17, 1903. I quote from this patent as follows:

"The object of this invention is to effect with substantial completeness the segregation of those pulverized mineral particles which have a preferential adhesion for water from those which have a preferential adhesion for a liquid immiscible in water—for example, oil, or a solution of bitumen in kerosene.

"This invention is for the treatment of the charge after the pulverized mineral, the oil or solution, and the water have been thoroughly mixed together, whereby nearly all of the mineral particles which exhibit adhesive preference for the oil or solution have been coated therewith.

"The invention is most useful when used to carry on one step of a process of my own invention, wherein the immiscible liquid employed is thin and light—as, for example, a solution of bitumen in kerosene; but the invention is also useful with oil processes
1512 for separating mineral particles. * * *

"The tank A is preferably cylindrical. Into it is to be charged the materials to be separated—to wit, pulverized ore, water, and some liquid lighter than water and immiscible therein, which will adhere only to the metallic mineral part of the pulverized ore—said materials having preferably been thoroughly mixed in another tank. The immiscible liquid may, as stated, be oil or a light hydrocarbon, or a solution of bitumen in a light hydrocarbon. The apparatus was especially designed for use with a charge consisting of ore, water, and the solution of bitumen in kerosene, and therefore the immiscible liquid will for convenience of description be referred to herein as the 'solution.' The charge should be very fluid and should preferably contain three or four times as much water as mineral, some of which water may be added to the mixture after it has been transferred to the tank A.

"Most of the solution and the solution-coated mineral particles rise immediately to the surface, from which they may be skimmed; but considerable quantities of the solution-coated concentrates are enveloped by and entrapped in the sands which settle to the bottom of the tank. For the primary purpose of freeing these particles from the sand and permitting them to float on the surface the vertical rotating agitator-shaft B and its adjuncts are provided.
1513 Arms D are secured to this shaft near the bottom of the tank, and as the shaft slowly rotates they gently lift the mass of sands from the bottom and overturn it and prevent it from packing, and thus permit the solution-coated particles to escape and float to the surface. * * *

"It is very desirable that some gas, preferably air, shall be blown into the charge near the bottom thereof. This gas assists in agitating the charge; but its chief value is in the assistance it renders

in floating the solution-coated particles to the surface. It is clear that some of these particles may be so large and heavy that the coating thereon may not be able to buoy them up, this being especially true in case the liquid used is thin and light, as the kerosene-bitumen solution. The gas-bubbles, however, not only tend to attach themselves to the solution-coated particles and to buoy them up after the fashion of balloons, but the water is caused to dissolve the gas to its maximum capacity. This dissolved gas tends to again separate from the water and attach itself in minute globules to the solution-coated particles, thus buoying them up and assisting their flotation.

"It is thought that any gas which will not chemically combine with the charge may be employed in the manner and for the purpose stated; but it is definitely known that air, carbon dioxid, hydrogen, and marsh-gas may be so used, air appearing to be rather
1514 the most efficient, as well as the cheapest. This gas may be injected in any way and by any means; but very efficient means for this purpose are shown in the drawings, said means consisting generally in making the shaft B and arms D hollow and providing the latter with discharge-openings and blowing the gas down through the shaft. * * *

"The solution is delivered from the pipe K to a series of radiating pipes *k*, which are secured to the arms D, and is discharged from branch pipes *k'*. This solution tends to attach itself to those particles not already coated, but which it will adhere to, and thus assists their flotation. The introduction of air and solution renders the separation substantially complete—that is to say, it causes substantially all of the particles which exhibit preferential adhesion for the solution to become coated thereby and floated to the surface. * * *"

The apparatus illustrated in the drawings of this patent is substantially identical with the "separating-tank" B of the preceding Kirby patent 809,959, except that two skimming-bars P are shown, and two perforated pipes T for directing air-jets onto the floating concentrates to direct it to and carry it over the settling compartment.

1515 These two Kirby patents show the following points:

(1) The selective action or preferential adhesion of oils generally, and especially kerosene or a solution of bitumen in kerosene, for the metalliferous constituents of ore, kerosene being specified as useful with sulfid ores.

(2) The use of "a sufficient amount" of the oil or oil solution to attain "excellent results" in the separation of the mineral by flotation.

(3) Varying the temperature at which the solution is used to regulate the preferential affinity.

(4) Adding acid to regulate the preferential affinity.

(5) The thorough mechanical agitation of the ore-pulp, acidulated, and the oil, by a rapidly rotating shaft having radial agitating blades, which type of agitator, employed by the defendant in this suit, is found to be a most efficient one for intermingling atmospheric air with the mass and thoroughly aerating the oiled mineral to produce a floating froth of concentrates.

(6) Further aeration of the mixture by the injection of streams of air or gas, such as carbon dioxid, hydrogen, or marsh-gas, acting to float the less buoyant, larger and heavier mineral particles trapped in the tailings, the separation of the froth of concentrates from the tailings by floating the scum over a series of vessels of the spitzkasten type, of progressively-increasing size with an up-current of water, and the delivery of the concentrates to a filter.

1516 I will next refer to a British patent, No. 12,778, granted June 4, 1902, to Alcide Froment, corresponding to his Italian patent No. 62,723. I quote from this British patent as follows:

"The following phenomena, studied by the inventor, have served as the basis of the process which forms the subject of this invention.

"1. When the natural sulphides reduced to powder are moistened by a fatty substance, they have a tendency to unite in spherules and to float upon the surface of water.

"2. This tendency is simply retarded by the specific weight, and opposed by the gangue which imprisons the moistened sulphides in its pulverulent mass.

"3. If a gas of any kind is liberated in this mass, the bubbles of the gas become covered with an envelope of sulphides and thus rise readily to the surface of the liquid where they form a kind of metallic magma.

"4. The formation of these metallic spherules is singularly active if the gas is in a nascent state.

"Thus for example, if in a test tube there is placed ten grammes of sulphuretted copper ore with its gangue, a gram of limestone, the whole reduced to powder, and if there is added thereto thirty grammes of water, a few drops of sulphuric acid and a thin layer of ordinary oil, and the mixture then agitated for a brief

1517 space, the whole of the chalcopyrite will instantly rise to the top of the liquid. The metallic spherules, pressed one against the other, will become grouped in a magma clearly separated from the rest of the liquid. If the limestone is in excess or readily attackable, the rapidity of the separation is so great that the chalcopyrite is forcibly projected outside the vessel. There is therefore a proportion to be sought for a given ore and limestone.

"The small quantity of gangue mechanically conveyed gradually falls and the sulphides remain in a state of almost complete purity. Such is the principle.

"Thus, the rapidity of the formation of the spherules and their ascension is in direct ratio to the quantity of gas produced in a given time.

Example 1.

"A cuprous ore containing 12% of chalcopyrite, 15% of iron pyrite, 20% of carbonate of iron, 16% of dolomite and calcite and 37% of various gangues have been submitted to my said process. It should be stated that this ore could not be enriched economically by any known means.

"Only a few seconds were necessary for completely separating the

sulphide of copper from the rest of the gangue in which no single trace of copper could be discovered by analysis.

Example 2.

"A calcitous or having 10% of lead and unmarketable
1518 with such a proportion, has been treated in the same manner and with the same success. There are several operations which are distinct but which are connected in carrying the process into practice; the formation of the spherules and their separation from the gangue, then separation of the product of the concentration from the oil and recovery of this latter for readmission to the cycle of operations. The products of the concentration form cakes."

This patent discloses the following points:

(1) The preferential affinity of a "fatty substance," such as "ordinary oil," for metalliferous particles, specifically natural sulfids reduced to powder.

(2) The use of a relatively small amount of oil, for example, "a thin layer" in the test tube experiment treating 41 grams of pulp, the purpose being merely to "moisten" the sulfids.

(3) The addition of a small amount of sulfuric acid to the pulp.

(4) The agitation of the entire mixture for a brief space.

(5) The liberation of a gas in the mass and the attachment of bubbles of the gas to the oiled sulfid particles.

(6) The consequent flotation of the sulfid, rising to the top of the liquid as a distinct magma or froth.

1519 (7) The removal of the concentrate froth and the separation of the oil therefrom for re-use.

In the test-tube experiment, limestone, that is, calcium carbonate, is added to the ore, reacting with the sulfuric acid added to the water to produce carbon dioxid or carbonic-acid gas, this gas being evolved in the nascent state and its bubbles becoming attached to the oiled sulfid particles, or each becoming covered with an envelope of the fine sulfid particles. The patentee notes that the amount and character of the limestone should be such that the evolution of gas is not too rapid, so as to project the contents of the tube out of its top.

In "Example 1," the specified ore naturally contains carbonates, to-wit, "carbonate of iron," "dolomite" (a double carbonate) and "calcite" (calcium carbonate), which are chemically like limestone. These carbonates would also react with the acid to evolve gas and float the oiled sulfid. The apparatus used for agitating the mixture of ore, water, oil and acid, in this "Example" or in a practical operation, is not described, evidently because Froment considered that suitable agitators were well known and would be chosen by those skilled in the art. Thorough agitation is obviously necessary to distribute the small amount of oil thinly over the innumerable small particles of sulfid to be coated.

Some simple experiments which I have made in connection with this Froment patent may be of interest, as follows:

1520 (1) A glass test tube holding 100 cubic centimeters was half filled with water, corked and well agitated for a brief

period. The air in the tube above the water was thus shaken into it and intimately distributed throughout it in the form of fine bubbles, which, however, quickly rose to the surface of the water and escaped as soon as the agitation was discontinued.

(2) The same experiment was repeated, with the difference that one drop of "red oil," the impure oleic acid used by defendant in carrying out his process, was first added to the water. In this case, the fine bubbles of air entangled in the water upon agitation did not quickly float, but remained distributed throughout the water for a considerable period, giving it a milky appearance.

(3) Ten grams of the ore which is being treated by defendant according to his process involved in this suit, finely-powdered, was taken and placed in the empty 100 cc. test tube. This ore, from the "Black Rock" mine of the Butte & Superior Copper Company, assayed about 20 per cent. zinc, equivalent to a content of about 30 per cent. of zinc sulfid. It also contained rhodochrosite, a manganese carbonate easily decomposed by sulfuric acid to give carbon dioxid gas. Upon adding thirty cubic centimeters of water to the ore in the test tube, some of the mineral floated, by reason of the air within the mass of ore and the films of air surrounding some of the small particles.

(4) A few drops of sulfuric acid were now added to the ore and water in the test tube, and the mixture was gently heated,
1521 whereupon gas was chemically liberated by the action of the acid on the carbonate and sulfid of the ore, evolving carbon dioxid and hydrogen sulfid, and considerable mineral rose to the surface of the liquid, floated by the adherent gas-bubbles, as in the well-known Potter and Delprat methods, heretofore referred to by me. This mineral, however, floated for a brief period only and then again subsided to the bottom of the tube.

(5) One drop of olive oil was now added to the acidulated water and ore in the test tube, and the tube was agitated for a brief space, whereupon a large mass of oiled and aerated mineral floated to the top, in the form of a magma or froth having the characteristics described in the Froment patent. It was found that agitation of the mixture for a brief period, such as was necessary to distribute the drop of oil over the innumerable particles of zinc sulfid in the ten grams of ore and moisten their surface with a film of oil, also thoroughly aerated the liquid, by the air shaken into it, just as in the experiment numbered (2) above. These fine bubbles of air throughout the mass, as well as the nascent gas chemically liberated throughout the mass, attached themselves to the oiled particles and assisted in floating them to the top as a froth.

(6) In order to oil the mineral particles without agitation, two drops of cotton-seed oil were dissolved in a few cubic centimeters of ether, and ten grams of the finely-powdered "Black Rock" ore heretofore described was moistened with the solution. The ether
1522 was allowed to evaporate, leaving the oil adhering to the mineral particles as a thin film. The oiled ore was then placed in a test tube, thirty grams of water were introduced, five drops of

sulfuric acid were added, and the whole was gently heated to cause the sulfuric acid to react on the carbonate in the ore. The nascent gas generated by the reaction attached itself to the oiled mineral particles and floated them to the top.

(7) Ten grams of the "Black Rock" ore were mixed, in one instance with one gram of limestone, or calcium carbonate, as prescribed by Froment, and in another instance with a half gram of rhodochrosite, the manganese carbonate occurring in the "Black Rock" ore, a thin layer or a few drops of olive oil were added, and a few droys of sulfuric acid. On warming to start the reaction, and agitating for a brief period, the oiled mineral floated as a froth.

I have heretofore stated that an agitating apparatus consisting of an open vessel in which is centrally journaled a vertical shaft having radial arms at its lower end, the shaft being rapidly revolved, such as is shown and described in the Schwarz patent 807,503, and the Kirby patents 809,959 and 838,626, constitutes an efficient means for aerating ore-pulp, or entangling atmospheric air and distributing it throughout the mass in innumerable fine bubbles, capable of attaching themselves to oiled mineral particles and floating them as froth. I have had considerable experience with apparatus of this type, both with a form of laboratory or test apparatus designed in part by the defendant, and called a "slide machine," and
1523 with the apparatus commercially employed by defendant, as installed by him in the mill of the Butte & Superior Copper Company, at Basin, Montana. In both the laboratory and commercial apparatus, the agitator is an open vessel in which is journaled a vertical shaft driven by a belt or gear at one end and having at its other end four radial arms or blades. I have also had built and have tested the agitator shown in the patent in suit, consisting of an open vessel in which is journaled a shaft carrying a hollow cone; and the agitator shown in Figure 1 of the Sulman & Kirkpatrick-Picard patent 793,808, consisting of an open trough near the bottom of which is journaled a perforated coiled pipe. Both the cone and the coiled pipe stir the water or ore-pulp vigorously and produce a froth, but appear not to be as efficient as the radial-arm type.

By using the Hyde slide machine, I have been able to carry out a process of separation corresponding to that of the Kirby patent 809,959. For this purpose, I took 500 grams of the finely-pulverized "Black Rock" ore which is treated by the defendant, and mixed it with from "three to five times" its weight of water, that is, with sixteen hundred cubic centimeters, acidulated by the addition of 1 cubic centimeter of sulfuric acid, and with an amount of kerosene equal to one-fourth that of the ore, that is, 125 grams. The temperature of the water used was 35° C. On agitating this mixture for thirty seconds by rotation of the central shaft having four radial arms, I was able to so thoroughly oil the sulfid and aerate
1524 the oiled particles by the air entrained by the agitation, without any injection of streams of air to float the particles entangled in the tailings, as to produce a floating froth of concentrates nearly half an inch thick. I also roughly imitated the operation of blowing in air carried out by Kirby, by the use of a single

tube pushed downward into the tailings at the bottom and moved about therein. By removing this first froth and repeating the operation of aerating by agitating, I was able to remove so much of the zinc sulfid from the ore as to leave the tailings comparatively light in color, that is, consisting largely of gangue.

Adjourned until Tuesday, May 7, 1912, at 10 A. M., same place.

Washington, D. C., May 8, 1912.

Met pursuant to adjournment. Present, counsel as before.

Direct examination of Eugene A. Byrnes continued:

(Answer to Q. 4 continued:)

By the use of this same Hyde slide machine, I have also carried out the process of the Schwarz patents 807,501 and 807,503, thoroughly mixing the ore with the oil before agitating and aerating the mass to produce the froth of concentrates. For this purpose I took 500 grams of the pulverized "Black Rock" ore, assaying 20.3 zinc, added 20 cubic centimeters of cotton-seed oil and mixed the whole thoroughly with a blade, giving a homogeneous mass
1525 having the consistency of molding sand. The slide apparatus was then filled to the normal level with 1700 cubic centimeters of water acidulated with one cubic centimer of sulfuric acid, its temperature being 76° F. The oiled ore was added and the mixture was then agitated for thirty seconds by driving the vertical shaft with radial agitating blades. A heavy froth was produced and removed. The mass was then reagitated for the same period, another froth made and removed, and this operation repeated until six froths had been separated. These froths, combined, were filtered and dried, and their weight was found to be 230 grams. The assayer reported their contents of zinc as 41.7 per cent. The assayer to whom I refer was W. R. Hocking, manager of "The Rombauer Assay Co.," of Butte, Montana. The tailings from these operations were also removed and dried, and their weight was found to be 277 grams, containing, as reported by the assayer, 0.7 per cent. of zinc. These tailings were nearly white and it was evident to the eye that the metalliferous constituents thereof had been almost entirely removed. In this experiment, I did not inject a gaseous fluid, such as air, steam, or carbon dioxid, which Schwarz states may optionally be used, relying simply on the agitation to effect the production of a froth. The specific gravity of cotton-seed oil being about 0.9, the 20 cubic centimeters which I used in this test was about 18 grams, or 3.6 per cent. of the ore treated. The zinc being present in the ore in the form of its sulfid, a content of 20 per cent. of zinc,
1526 as reported, corresponds to a content of its sulfid of about 30 per cent. The 500 grams of ore therefore contained about 150 grams of the zinc sulfid, and the 18 grams of cotton-seed oil were thus 12 per cent. of this metalliferous constituent of the ore.

I also carried out the operation of the Everson patent 348,157, by using the Hyde slide machine to effect the thorough agitation of

the oiled ore and removal of the sand by means of acidulated water, floating off the concentrates. This Everson process is similar to that of Schwarz, in that the ore is oiled before it is agitated with acidulated water. For this purpose, I employed the materials and proportions specified in lines 75-92 of the patent, using as an acid the sulfuric acid mentioned in lines 8 and 119. I used eight times the amount specified, that is, sixteen ounces of the pulverized "Black Rock" ore, and 24 fluid drams of petroleum, in this instance having a gravity of 33° Beaume. I thoroughly mixed the ore and petroleum, producing a homogeneous mass having the consistency of damp sand. I then placed in the slide machine 1600 cubic centimeters of water, acidulated with three cubic centimeters of sulfuric acid, having a temperature of 27° C. The agitator of the machine was then started and the oiled ore gradually added. The agitation was continued for thirty seconds, producing a good froth, which was removed. The mixture was then reagitated for thirty seconds, and the second froth removed. In order to maintain the acidity of the water, to assist in cutting away the sand from the oiled ma-
1527 terials, as described by Everson, one cubic centimeter of sulfuric acid was now added. The mixture was then reagitated several times and four froths removed. One cubic centimeter of sulfuric acid was again added and the mixture was successively reagitated three more times and three froths removed. The nine froths were mixed and filtered. The residual concentrates were then washed several times with gasoline to entirely remove the oil therein, and were dried and weighed. Their weight was 144 grams. The tailings were nearly white or quite light-colored, the greater amount of the zinc sulfid having been removed therefrom, as was apparent to the eye.

My tests of the apparatus which I had built in accordance with Fig. 1 of the Sulman & Kirkpatrick Picard patent 793,808 show that it is capable of producing a very satisfactory froth of concentrates. This apparatus, which I had built to scale from the drawing of the patent, had an agitator of perforated coiled gas-pipe, three-eighths of an inch in internal diameter, and about four feet long. This coil, when rapidly rotated by power produced a very vigorous agitation and stirring of the liquid in the tank or trough. I tested it without supplying compressed air to the end of the pipe, and found that while it would stir in some air from the surface of the liquid, it was not an efficient means for entangling atmospheric air, as is the Schwarz, Kirby and Hyde agitator with radial arms. When the apparatus was run on an ore-pulp consisting of warm water and pulverized
1528 "Black Rock" ore, and compressed air carrying "red oil" was supplied to the end of the coiled pipe, the air escaping from the perforations of the pipe was thoroughly beaten through the pulp, coating the metalliferous particles with a thin film of oil and attaching bubbles of air to the oiled particles, which were thus raised to the surface by gaseous flotation, producing a thick and satisfactory froth. I skimmed off many handfuls of this thick froth and found it very heavy by reason of its high content of zinc sulfid. It was quite clear that several repetitions of the agitation and defrothing, or con-

tinued agitation and removal of the froth, would have separated a very considerable amount of the zinc sulfid from the ore, quite possibly rendering the apparatus a commercial one.

I have repeatedly operated the process of the Froment British patent 12,778 of 1902, using the Hyde slide apparatus to effect the brief agitation and frothing, and using different kinds of oil and widely-differing amounts of oil. The data of some of these Froment operations, using the finely-pulverized "Black Rock" ore having a zinc content of 20.3 per cent., are as follows:

A mixture of 492 grams of ore, 1,700 cubic centimeters or grams of water, at 70° Fahrenheit, 0.3 cubic centimeters of cotton-seed oil and one cubic centimeter of sulfuric acid was agitated and defrothed five times. The fine froths were filtered and dried, giving concentrates having a weight of 170.5 grams, reported by the assayer to contain
50.0 per cent of zinc. The tailings weighed 315.5 grams and
1529 had a reported zinc content of 4.2.

The process was repeated under precisely the same conditions, except that 20 cubic centimeters of cottonseed oil, or 66 times as much, was used. Six froths were made and removed, and the dried concentrates plus some oil therein, weighed 211 grams and had a zinc content of 48.3 per cent. The tailings, plus some oil therein, weighed 292 grams and contained 1.0 per cent of zinc.

The process was repeated under precisely the same conditions, except that 20 cubic centimeters of Ehrmann's California olive oil was used. Five froths were made and removed, the concentrates, plus some oil, weighing 219 grams and having a zinc content of 44.3 per cent. The tailings, including some oil, weighed 274 grams and contained 0.6 per cent. of zinc.

The process was repeated under the same conditions, but using 20 cubic centimeters of "red oil," impure oleic acid, from Charles T. Perry & Co., of Helena, Montana. Three froths were made, removed and dried. The weight of the concentrates was 65 grams and their reported zinc content was 42.2 per cent. The tailings were not cleaned, but showed on their surface small particles of aggregated mineral, or "flocks," perhaps half a millimeter, or one-fiftieth of an inch, average diameter.

The amount of cotton-seed, olive and "red oil" used in the last three operations was more than 3.6 per cent. of the weight of the ore, and more than 12 per cent. of the weight of the zinc sulfid in the ore.

1530 The process was repeated under the same conditions, using 500 grams of ore, except that ten cubic centimeters of "red oil" was used. Four froths were made, removed and dried. The concentrates therein weighed 202 grams, and had a reported zinc content of 47.5 per cent. The tailings were very white, weighed 288 grams, and contained a reported zinc content of 1.1 per cent. It should be noted that the "red oil" used in this test was a special or somewhat purer form of oleic acid than that used in the preceding run, more of the solid fatty acids, stearic and palmitic, having been removed by the maker, Charles T. Perry & Co., rendering it thinner and less viscous, pasty or solid at ordinary temperatures.

I have made some tests of the apparatus shown in Figure 1 of the patent in suit, the agitator or mixing vessel and the froth-separating apparatus being made for me to scale as closely as could be determined, the cylindrical vessel containing the agitating cone having a height of 12 inches and a width of 6 inches.

In one run, this vessel was filled with water to the maximum height permissible with rapid rotation of the cone without throwing the water out of the vessel, which was found to be two-thirds of its height, or 8 inches. The amount of water then contained was 3200 cubic centimeters. To this water was added one cubic centimeter of sulfuric acid and three-fourths of a cubic centimeter of "red oil." The water was previously heated and had a temperature of 35° C. The cone mixer was now rapidly rotated and 500 grams of pulverized "Black Rock" ore
1531 was introduced, the agitation being continued for ten minutes. The stop-cock in the pipe leading from the vessel to the froth-separator was then opened, and most of the mixture siphoned out. The cone being maintained in motion, wash-water was added to remove the residue, and the vessel was slightly tilted to empty out the portion contained in the concave bottom. Some froth floated down the shallow trough and over the body of the water contained in the spitzkasten, passing on into the launder and being collected and filtered. Considerable mineral, in the form of fine individual oil particles, also floated down on the surface of the water, as a mere film supported by surface tension. This was also delivered to the launder and collected with the froth, care being taken to recover all of the floating mineral, whether froth or film. I was not able to verify the statement in line 92 of page 1 of the patent in suit, that the scum or mineral floated derives its power of flotation "mainly from the inclusion of air-bubbles introduced into the mass by the agitation," by reason of the film flotation of so much of the mineral distinct from the aerated froth. All of the concentrates floated and collected were dried and their total weight was 33 grams. The tailings showed hardly any perceptible change in color from the original ore, as was to be expected from the comparatively small amount of mineral removed by flotation.

I then carefully washed out all of the apparatus and made another run, with 3,200 cubic centimeters of water at 35° C., 1.4
1532 cubic centimeters of "red oil," 2 cubic centimeters of sulfuric acid and 500 grams of pulverized "Black Rock" ore. The agitation was here continued for five minutes, all of the mixture in the vessel was washed out, with agitation, and all of the mineral floating as froths or films was collected and dried. The weight of the concentrates recovered was 49 grams. The tailings were very little changed in color.

From my study of the prior art, and from my tests of the processes disclosed therein, as well as of the process in suit, I am entirely unable to find any point of novelty in the process described and claimed in the patent in suit, so far as it is carried out by the use of the apparatus shown in Figure 1. I disregard the modified apparatus of Figure 2, and the supplemental or modified processes involving solu-

tion of air in the agitated pulp by superatmospheric pressure, or distribution of the tailings in a thin layer on a shaking-table or the like, as described on page 2, line 103, to page 3, line 34, and on page 2, lines 25 to 39, these modifications constituting the subjects of separate applications referred to, which have since matured into patents.

I find a clear disclosure of the preferential affinity of oils and fats for the metalliferous constituents of ores, especially sulfids, or for graphite, in the specified prior patents to Everson, No. 348,157; Elmore, 676,679 and 689,970; Glogner, 736,381; Good, 745,960; Cattermole, 777,273; Cattermole, Sulman & Kirkpatrick-Picard,
1533 Nos. 777,274 and 788,247; Sulman & Kirkpatrick-Picard, No 793,808; Schwarz, 807,501 and 807,503; Kirby, 809,959 and 838,626; and Froment British, 12,778 of 1902.

I find a clear disclosure of the use of acid, for example, sulfuric acid, including small amounts of acid, in processes of oiling the metalliferous constituents of ore, with statements that acid increases the preferential affinity of oil for the metalliferous constituent, in the specified patents to Everson; Elmore, No. 689,070, which claims this feature, i. e., the enhancement of the selective action of oil by the use of very small quantities of acid, instancing sulfuric and oleic acids, added to the ore-pulp or oil, the quantity being varied, however, to produce the best results; Cattermole, No. 777,273, acknowledged in the patent in suit, specifying a fraction of one per cent. and mentioning sulfuric acid; Cattermole, Sulman & Kirkpatrick-Picard, No. 777,274, also acknowledged in the patent in suit, and No. 788,247, the description of which is identical as to the mode of oiling, and which states that any slight excess of acid beyond that acting to decompose the soap solution used as a source of the oiling agent will react on carbonates or easily-decomposable sulfids in the ore to generate gas; Sulman & Kirkpatrick-Picard, No. 793,808; Schwarz, 807,503; Kirby, 809,959, which particularly notes that the preferential action may be regulated by the addition of acid; and Froment, 12,778 of 1902.

The flotation of oiled mineral particles by the attachment
1534 thereto of films or bubbles of air, or gas, or, otherwise stated, by the adhesion of the oiled particles to bubbles of air or gas, is clearly disclosed in the Cattermole, Sulman & Kirkpatrick-Picard patent 788,247; in Sulman & Kirkpatrick-Picard, 793,808; Schwarz, 807,501 and 807,503; Kirby, 809,959 and 838,626 and Froment, 12,778 of 1902. And the use of agitators which, as shown by my tests, will aerate a mixture of oil and acidulated ore-pulp by entangling atmospheric air and beating it through the mixture in the form of fine bubbles, attaching themselves to the oiled mineral particles, is described in Everson; Cattermole, 777,273; Cattermole, Sulman & Kirkpatrick-Picard, 777,274; Schwarz, 807,501 and 807,503, the latter illustrating and describing defendant's agitating device, a vertical shaft with agitating blades; and Kirby, 809,959 and 838,626, also illustrating defendant's stirrer with radial blades. Glogner, 736,381, illustrates an oscillating agitating vessel, in which the mixture of ore-pulp and water is thrown violently against one end of the

vessel, the wave falling back through the air, thus imitating the aeration and frothing produced by an ocean wave. Froment, as I have noted, confines his description to the process and its principles, leaving the type of agitator to be determined by the user. In his test-tube experiment, agitation sufficient to coat the mineral particles with a thin film of the oiling agent also thoroughly aerates the mixture, the fine bubbles of air distributed throughout it, and attaching themselves to the oiled particles, acting with the chemically-evolved gas to float them. The function of the gas-bubbles
1535 is identical, whether they be of atmospheric air shaken or beaten into the mixture; air or gas injected in streams; gas chemically evolved throughout the mixture; gas electrolytically evolved by decomposition of the liquid; gas liberated by first increasing the amount in solution in the liquid by the use of pressure and then releasing the pressure; all described in the patents referred to by me; air or gas normally in solution in the liquid and evolved by creating a partial vacuum over its surface; or gas produced by boiling the liquid, as described in patent No. 835,143 to Henry L. Sulman. Another patent to Sulman, Kirkpatrick-Picard & Ballot, No. 835,479, refers to the fact that several methods are known for producing the gaseous films or bubbles used to float the particles.

The fact that oils and fatty acids in general have a preferential affinity for metalliferous matter and graphite is recognized by the patent in suit. The particular oiling agent described, oleic acid, and its liberation in situ in the pulp by the decomposition of a soap solution, are disclaimed in the patent in suit as described in the Cattermole patent No. 777,274.

The fact that widely different amounts of the same oiling agent, indiscriminately over as well as under one per cent. or a fraction of one per cent. of the weight of the ore, may be successfully used to oil the mineral and float it by attached gas films or bubbles is shown by the prior patents referred to by me, and by the practical tests which I have made and described. It is also to be noted that the limita-
1536 tion of some of the claims of the patent in suit to a proportion of the oiling agent amounting to a fraction of one per cent. on the ore, does not exclude the proportions specified in the Cattermole patent No. 777,273, in which the percentage of oil is based on the weight of the metalliferous mineral in the ore, and the usual range is stated to be from 4 to 6 per cent. of oil by this weight of mineral.

The use of warm water, or a warm mixture, having a temperature of say 30 to 40° C., as described in the patent in suit, is an obvious and necessary expedient when oleic acid is the oiling agent, since this acid is solid at all lower atmospheric temperatures, and must be heated to a temperature at which it is thinly liquid, to enable it to be distributed throughout the ore as a minute film covering the metalliferous particles. Oleic acid is one of the constituents of and is ordinarily derived from animal fats, such as tallow. Its behavior may be understood by referring to analogy of butter. Iced butter is solid, non-plastic and difficult to spread. At lower and moderate atmospheric temperatures, it is plastic and may readily be spread.

If we wish to distribute butter as a thin film over the surface of small grains, for example popcorn, we slightly raise its temperature until it is thinly liquid. I have made some rough tests of the impure oleic acid used by defendant in his flotation plant at the Basin, Montana, mill of the Butte & Superior Copper Company, and which was also used by me in all of my tests, except the one in which,
1537 with the slide machine, I used ten cubic centimeters of a special thin oleic acid, as stated. For this purpose, I unscrewed the plug in the side of one of the iron drums in which this oil is received at Basin. This drum had been lying in the sun outside the mill for some time. I found that the "red oil" in the drum was entirely solid, and on pushing a thermometer down into it 12 inches found that its temperature at the center of the drum was 7° C. With a stick I took out some of the solid oil, about 400 cubic centimeters, placed it in a beaker and warmed it on an electric hot-plate in the laboratory. When a small portion of the oil had become liquefied, I removed the beaker from the plate and let it stand for a few minutes. The temperature of the liquid portion was then 18° C. I then returned it to the hot-plate and continued the heating until all the grains of solid fat suspended in the liquid had become melted. The temperature of complete fluidity, with thorough stirring, after removal from the hot-plate, was about 38° C. As the temperature of the ore-pulp supplied to the Hyde flotation apparatus at the Basin plant was normally very low, far below the solidification point of "red oil," it was, of course, necessary to warm the pulp in the agitator in order to keep the oil liquid and enable it to coat the zinc sulfid particles. The flume supplying this mill with water, on different days when I examined it, was coated with ice, although the weather in April was bright and sunny. The temperature of the water in this flume, as tested by me at different times, was only 1 or 2
1538 degrees above freezing. And the temperature of the ore-pulp delivered at the bottom of the mill to the elevator carrying it to the Hyde flotation plant was found by me to be 3° C. I took a quart of this pulp in a thin vessel, carried it up to the flotation plant and allowed some of the oil feeding to the first agitator to drop upon its surface, whereupon it solidified at once.

The heating of the oil, or mixture of pulp and oil, or its maintenance at a proper temperature to keep the oil liquid and effect the oiling of the metalliferous particles with a thin film, is described in the specified Everson patent; in Sulman & Kirkpatrick-Picard 793,808; in Schwarz 807,501 and 807,503; and in Kirby 809,959.

The patent in suit is very vague as to the details of the process and as to the proportions of oil and acid to be employed, indicating that preliminary tests are necessary with different ores to determine the proper amount. Although an "example" of the application of the process to a particular ore is described, the proportion of oleic acid to be added to effect the oiling is specified as "say from 0.02 per cent. to 0.5 per cent. on the weight of the ore," leaving it to the user to determine whether he should use the smaller proportion, the larger one, twenty-five times as much, or some intermediate one. Later, the description states, in the most general terms, that the proportion

may be "under 0.1 per cent. of the ore." So again, the amount of sulfuric acid or other acid or salt to be added may be any frac-
1539 tion of 1 per cent. or up to 1 per cent. The particular "different oily substances" which are suitable "with different ores" are not described, nor any characteristics which enable the user to determine the proper one. The agitator or mixing vessel shown is confessedly old with Cattermole, and is relatively inefficient. The spitzkasten froth-separating apparatus is a very old device, and is shown in the prior art cited by me. It is therefore my opinion that this patent in suit describes and claims no new process, and employs no new principles or apparatus, except for the subject-matter expressly disclaimed as that of other applications then pending but since patented.

By Mr. Williams: Notice is given of a motion to strike out as incompetent all parts of the above answer of the witness referring to patents not pleaded by the defendant; to strike out as irrelevant all descriptions of tests alleged to be of the processes of prior patents not carried out with the procedure or in apparatus such as are disclosed in such patents. It is consented, however, that the defendant may amend his answer to include therein such patents above referred to as may not have been pleaded, subject to the usual condition that should he prevail upon any of these patents he may not recover costs for any proceedings prior to the deposition of the present witness.

Adjourned until Thursday, May 9, 1912, at 10 A. M., same place.

1540 Washington, D. C., May 9, 1912.

Met pursuant to adjournment. Present, counsel as before.

Direct examination of Eugene A. Byrnes continued:

By Mr. Williams: It is noted that the experiments above described by the witness, not having been made in the presence of opposing parties, the observations and conclusions of the witness are objected to as not the best evidence, unless an opportunity is afforded to complainants to repeat these experiments, and the apparatus used in these experiments are offered in evidence.

It is noted that of the patents above referred to by the witness, the following patents were issued subsequently to the application for the patent in suit and are therefore not prior patents, even in the present state of the proofs: Sulman & Picard 793,808, Schwarz 807,501, Schwarz 807,503, Kirby 809,959, Sulman, Picard & Ballot 835,143, Sulman, Picard & Ballot 835,479, Kirby 838,626.

Q. 5. Do you know of any instance in the art of separating minerals, other than those cases to which you have referred, in which a liquid carrying minerals is aerated for the purpose of assisting in the separation? If so, please describe such matters as you have knowledge of.

A. It is common practice in the art of treating minerals
1541 by the cyanid process to thoroughly aerate the ore-pulp, by a variety of methods, for example by injecting streams of air;

by flowing the pulp over an aerating surface, in a thin sheet, in contact with atmospheric air, or by beating air into the pulp by an agitator. An agitating apparatus for this purpose employing an open tank, in which is journaled a vertical shaft carrying four radial blades at its lower end is shown, for example, in U. S. patent 729,805, granted June 2, 1903, John and Leo Stoveken, in Figs. 2 and 3. I quote from this patent as follows:

"Q Q, agitation-tanks, of which six are preferably employed, said tanks being arranged one below the other and being provided with discharge-conduits R, so as to enable the mixed solution and comminuted ore to flow by gravity from the tank nearest the pulverizer H to the next lower tank, and so on until they reach the last tank—i. e., the lowest tank, and that farthest from the pulverizer. * * *"

"In the practical operation of our apparatus it will be observed that the solution is in contact with the ore incident to the grinding of the ore by the rolls E and F and incident to the reduction of the ore to a finely divided or comminuted state in the pulverizer H. By virtue of this and the subsequent violent agitation of the comminuted ore and solution in the tanks Q the solution reaches all of the values no matter how small the particles of ore in which the same are contained, * * *"

1542 "agitating-blades connected together and to the head *h* and curved in the direction of their length and inclined in the direction of their width, Figs. 2 and 3, whereby they are adapted to throw the comminuted ore and solution outward after the manner of a centrifugal pump and upward like a plow; *j j*, stationary wings connected to the side-wall of the tank and having for their purpose to force the mixture of comminuted ore and solution back to the center of the tank when the same is thrown outwardly by the blades *i*, and *k* a pipe let into the cylinder *a* below the piston *c* and designed, in common with pipes *k* of the other cylinders Q, to be connected with a source of fluid-pressure supply. When the shaft *e* is rotated by a driving connection intermeshed with the miter-gear *g*, it will be observed that the material in the tank will be thrown outwardly and upwardly against the wings *j*, which will roll it back into the center of the tank. This is materially advantageous, since in addition to being kept in suspension the material is worked up and down, and consequently the cyanid solution is caused to absorb the necessary oxygen and effect a rapid and complete dissolution of the gold and silver contained in the ore. * * *"

The stationary wings *j* are an important feature to produce thorough aeration by agitation in cylindrical open vessel, since they prevent the rotation of the pulp as a mass, substantially at the same speed as the radial arms. The same result is produced in the
1543 apparatus used by the defendant by the use of a square tank.

The agitator of the patent in suit is defective as an aerating machine, as I noted in operating it, by reason of the specified rotation of the entire body of pulp within the smooth cylindrical vessel.

By Mr. Williams: Notice is given of motion to strike out the above answer as incompetent, for the reason that the patent referred to has not been pleaded, subject to the consent stated in the objection to Q. 4.

Q. 6. Will you state how you find that the patentees of the patent in suit define the extent of the agitation to which they refer in the patent, stating also whether you find anything novel in agitation of such a character?

A. In the specific "example" of the application of the process given on page 1, lines 70-101, of the patent in suit, the statement as to agitation is as follows:

"* * * The mixture is warmed, say, to 30° to 40° centrigrade and is briskly agitated in a cone mixer or the like, as in the processes previously cited, for about two and one-half to ten minutes, until the oleic acid has been brought into efficient contact with all the mineral particles in the pulp. * * *"

All processes dependent on the oiling of the mineral particles in the pulp require that the oil be brought into efficient contact with these particles. While this result can be effected without agi-
1544 tation, by dissolving the oil in ether and saturating the dry ore with the solution, in practice, and in the various oil-gas flotation processes set forth in the prior art referred to by me, the oiling is effected by mechanical agitation, which would obviously be continued until the mineral particles had been brought into contact with the oil and coated therewith.

Q. 7. What significance, if any, do you attach to the word "mainly" as used in line 92, page 1, of the patent in suit?

A. The statement that the flotative power of the froth or scum is derived "mainly from the inclusion of air-bubbles introduced into the mass by the agitation" is a recognition of the fact that in the process of this patent some of the mineral is floated without included air-bubbles, that is, as individual oiled particles, floating as a film by reason of surface-tension. As stated in my answer to Q. 5, in my operation of an apparatus constructed in accordance with Fig. 1 of the drawing of this patent, I found that a considerable portion of the mineral was so floated as a film and not as a froth.

Q. 8. Assuming the practice of a process of the general character set forth in the patent in suit, using an amount of acid insufficient to cause chemical action on the metalliferous minerals present, do you know of any advantage which would result from the use of such an amount of acid, other than some slight economy possibly resulting from the reduction of the quantity of acid to the point specified?

A. Assuming, without intending to admit, that an acid
1545 capable of reacting on the metalliferous minerals would not so react if used in small proportion, I see no advantage to be derived from the use of such small proportion, except the saving in the cost. Acid capable of reacting on constituents of the ore to produce a gas has the double function of increasing the preferential affinity of the oil for the mineral, which requires an amount not

definitely specified in the patent in suit, and which doubtless varies with different ores; and of assisting in the flotation by the production of bubbles of gas, evolved in a nascent state, and in minute and extended subdivision throughout the body of pulp, wherever the acid comes in contact with a gas-generating particle of ore.

Q. 9. In the patent in suit I find frequent use of the expression "powdered ore." Will you explain the meaning of this expression, both as used in common parlance and whether it would have any different meaning in connection with a metallurgical operation?

A. "Powdered ore" is ore which has been converted into a powder, as by crushing, grinding or passing between rolls. I do not apprehend that the term is used with any other or unusual significance in the patent in suit. The patentees speak of crushing the ore "to ninety mesh to the linear inch, (half of which ore will pass through one-hundred and fifty mesh sieve,)"; also that "Crushed ore is fed from a hopper C into the vessel (A) by a band B." "Crushed ore or similar finely-divided mineral is fed into the vessel *a*." In other words, the dry powder of ore, which may be crushed to the
1546 size specified, is delivered into the mixing vessel A or *a*. The band "B" shown in Figure 1 is adapted to convey such dry powdered ore from hopper C into vessel A.

Q. 10. Would the band B to which you have referred be adapted, in your opinion, to convey a freely-flowing pulp from the hopper C to the vessel A?

A. No, it would be entirely unsuited for such purpose, since the pulp would then flow off from the belt in all directions, rearwardly and laterally as well as toward the vessel A.

Q. 11. Do you find anything in the patent in suit that would guide one as to the amount of oil and acid to be used further than or more definite than the directions set forth in the Froment British patent to which you have referred?

A. I do not. The patent in suit states that a preliminary test is necessary with any particular ore, to determine the oily substance to be used, and in the specific "example" simply specifies "a very small proportion of oleic acid (say, from 0.02 per cent. to 0.5 per cent. on the weight of ore), a very wide range, with no statement or indication as to whether the 0.02 per cent. is preferable or the higher limit, twenty-five times as much, or what conditions are to determine the amount to be used. In the Froment patent 12,788 of 1902, it is stated that the sulfids reduced to powder are to be "moistened" by the fatty substance, indicating that a sufficient amount should be used to coat the surface of the particles with a film. In the
1547 test tube example, for a charge consisting of 41 grams, a "thin layer" of oil is specified.

As to the acid, while the patent in suit disclaims any intention to have the acid act on the ore and generate gas, but signifies that it is used simply to increase the preferential affinity of the oil for the mineral, it is stated that any indefinite amount up to, e. g., 1 per cent. of sulfuric acid by weight of the water may be used. Whether 1 per cent. or one-hundredth of 1 per cent. is preferable is not stated, nor is any information given to enable the user to determine which

proportion should be adopted, or what conditions control the amount. Here, also, as with the oil, the amount must evidently be determined by experiments or preliminary tests with the particular ore to be treated. One per cent. of sulfuric acid on the weight of the water which I used in operating the process of this patent in suit, being 3200 grams of water, would be 32 grams, for 500 grams of ore treated, an amount sufficient to decompose over 37.5 grams of rhodochrosite, the manganese carbonate present in the ore, or about 7.5 per cent. of its weight of this mineral, which is entirely decomposed by sulfuric acid with the evolution of carbon dioxid. The Froment patent states that for a pulp consisting of 10 grams of sulfid ore, one gram of limestone or calcium carbonate, and 30 grams of water, "a few drops of sulfuric acid" are suitable.

Q. 12. In your opinion, would the apparatus shown in Fig. 1 of the drawing of Sulman & Picard patent 793,808, be operative to accomplish the desired result without vigorous rotation of the
1548 finely coiled perforated pipe B¹?

A. It would not. I tested the apparatus which I had built in accordance with Figure 1 of this patent by supplying compressed air to the coiled pipe without rotating it, and found that the air simply streamed upward in lines of bubbles from the numerous perforations in the pipe, without thoroughly aerating or frothing the liquid. Upon rotating the coiled pipe, however, the vigorous agitation produced by its several turns forcibly displacing the liquid caused the issuing air to be thoroughly beaten into the pulp, aerating it and producing a froth carrying the oiled mineral.

Q. 13. Would it be possible to efficiently oil the mineral particles by means of said apparatus without vigorous rotation of the coiled pipe?

A. It would not, since the oil is introduced by the current of compressed air, being carried thereby as a fine spray or vapor. Without rotation of the coil, the oil would simply rise to the surface with the air issuing from the stationary perforations of the pipe. The same rotation and beating action is necessary to bring the oil into contact with the mineral particles, as to aerate them.

Q. 14. Would there, in your opinion, be any difference in the action of carbon dioxid produced by the action of acid upon a carbonate forming part of an ore and its action upon some carbonate added to the ore in a process of the character described in the patent in suit and in the Froment British patent and other patents to which you have referred?

1549 A. The carbonate would react in the same way, and the same amount would evolve the same amount of gas, whether it was naturally present in the ore and was exposed to the acid by powdering the ore, or was added to the ore as a powder. This fact is recognized by Sulman & Kirkpatrick-Picard, two of the grantees of the patent in suit, in patent 788,247, granted jointly to them and A. E. Cattermole, in which they state that—

"If the ore contains a carbonate, any small excess of the acid used to decompose the soap or similar alkaline compound will also liberate

bubbles of carbonic acid, which will attach themselves to the fatty acid-coated mineral particles and float them to the surface, or a suitable carbonate (or other substance capable of liberating a gas on the addition of a suitable acid, such as an easily decomposable sulfid, etc.) may be initially added to the ore mass for such purpose."

The Froment patent, No. 12,778, of 1902, also gives two examples, in one of which a carbonate is added to the ore to evolve gas with the sulfuric acid, and in the other of which the ore naturally contains carbonates. "Limestone," specified as added to the ore in the first example, is "calcite," specified as present in the ore of the second example.

Q. 15. I hand you a certified copy of the application for and proceedings leading to the grant of Cattermole, Sulman & Kirkpatrick-Picard patent No. 788,247, and ask your opinion as to the
1550 relation between the quantity of oleic acid which the applicants state they use, as indicated in the expression that they "only seek to coat every particle of metalliferous matter as thinly and evenly as possible," and the quantity of oleic acid specified in the patent in suit? The expression above quoted occurs in an argument filed by the applicants for said patent December 31, 1904, the paper in question being designated "Paper No. 4."

By Mr. Scott: The papers referred to in the preceding question are introduced in evidence and marked by the Notary "Defendant's Exhibit Certified Copy of File-Wrapper and Contents of Patent 788,247."

By Mr. Williams: It is noted that statements made in the prosecution of another application for its patent than the patent in suit appear to be irrelevant to the issues herein, and the exhibit and the question are therefore objected to as irrelevant as well as incompetent.

A. As I noted in my answer to Q. 4, this application Ser. No. 200,649 was filed simultaneously with another application by the same parties, No. 200,650, which latter matured into patent 777,274, acknowledged in the patent in suit; and the description of the method of oiling the mineral by a fatty acid, etc., liberated from a soap solution added to the pulp is almost identical in both, lines 10-56 of page 1 of 777,274 being nearly the same as lines 9-53 of page 1 of 788,247. The only differences which I find be-
1551 tween the two in this respect are the interchange of the serial numbers, in the cross-references in each application to the other; the use of the word "wetted" in line 47 of 788,247, instead of "wet" in line 48 of 777,274; and the clause, "The mineral particles now attached to or more or less coated or inclosed by films of fatty or resin acids," in lines 53-55 of 788,247, instead of "and the mineral particles become attached to or more or less coated by films of fatty or resin acid," in lines 54-6 of 777,274. The descriptions of both specify the addition to the ore-pulp of "a small quantity of soap solution" and a "small amount of mineral acid" to decompose the soap and liberate the fatty or resin acid which is the oiling agent. The specified purpose in both is that the "mineral particles" shall

become "attached to or more or less coated (or inclosed) by films of fatty or resin acid (acids)." That is, no distinction is made between the amount of soap and mineral acid to be used, and the amount of fatty or resin acid to be set free therefrom and used to coat the mineral particles with a film, whether the coated particles are to be caused to adhere and form granules, as in the specific separation method of 777,274, or are to be floated by gas bubbles, the specific process of 788,247. The statement quoted in the question from the file-record of 788,247, that applicants "only seek to coat every particle of metalliferous matter as thinly and evenly as possible" with the oleic acid liberated from the soap solution, would therefore apparently apply with equal force to the oiling process of 777,274.

1552 I should say, therefore, that the statement in the patent in suit, referring to patent 777,274—

"We have found that if the proportion of oily substance be considerably reduced—say to a fraction of one per cent. on the ore—granulation ceases to take place"

was based on a misapprehension or error as to the proportion of oil actually contemplated in patent 777,274, or its complement, 788,247. In other words, I should say that patents 777,274, 788,247, and the patent in suit all describe processes of separation based on the initial oiling of the mineral particles with a bare film. As I understand the process of the patent in suit, it also seeks to initially "coat every particle of metalliferous matter as thinly and evenly as possible" with the oiling agent, and the proportion of oily substance must be sufficient to do this, being specified in the patent in suit as a "fraction of one per cent. on the ore." This is an amount which, as I have heretofore stated, overlaps or includes the amount of oil specified in the Cattermole patent No. 777,273, to-wit, "four per cent. to six per cent. of the weight of metalliferous mineral present in the ore."

Q. 16. Have you visited the Black Rock Mine of the Butte & Superior Copper Company, and the flotation plant which operates upon part of the ore from that mine; if so, will you kindly describe the ore which occurs in that mine, the operation of the flotation plant as you observed it, and any experiments which you performed in connection therewith?

1553 By Mr. Williams: Objection is made to any description of the operation of any flotation plant as called for by the question as secondary and incompetent, this objection being based upon the assumption that the plant referred to is not the experimental plant which is said to have been destroyed.

By Mr. Scott: All of the question after the first sentence is withdrawn.

A. Yes.

Q. 17. Did you observe whether any carbonates are present in that ore and the extent of their distribution in the ore; if so, please

state what carbonates and to what extent they are distributed through the ore?

A. I thoroughly examined different portions of this Black Rock Mine ore, walking many hundreds of feet through the different levels. I noted that the ore is quite variable in different sections, both as to its content of blende and the character of the gangue rock. I found throughout the mine, in the various portions which I visited, that the manganese carbonate, rhodochrosite, is prevalent. This carbonate, which is readily recognizable, having a pinkish color, occurs in many places in large veins and masses, sometimes several feet in width. In many instances, a mass of well crystallized bright pink rhodochrosite occurs in a body of the richest blende ore. I took a great many specimens of the ore from different parts of the mine, including pieces rich in blende and rhodochrosite, and
1554 large blocks of the latter alone. One day while at the mill at Basin, I walked over and carefully examined the ore in all of the steel railway cars on the siding, whence it is elevated to the mill, and I found the rhodochrosite distributed throughout all of it, as I should have anticipated from my examination of the mine. I also took many samples of the ore carrying blende and rhodochrosite from these various cars. I had all of the samples taken by me, both from the mine and from these cars, shipped to my laboratory in this city, where I have since examined them. I talked with the assayer, Mr. W. R. Hocking, of Butte, Montana, who continually tests all of the Black Rock ore milled by the Butte & Superior Copper Company at Basin, as to the prevalence of rhodochrosite in the ore, and he stated that it occurred in every sample. I also talked with the assayer at the mill at Basin, and he stated that he sometimes made as many as sixty or seventy analyses of the Black Rock ore per day and invariably found the samples to contain the rhodochrosite.

By Mr. Williams: Notice is given of motion to strike out all parts of the above answer, repeating statements made by assayers, as hearsay and incompetent.

Q. 18. Have you ever performed any experiments with a full-sized flotation plant for separating minerals with a view to determining the conditions as to the quantity of oily matter, quantity of acid, and other conditions necessary to the successful operation of a
1555 flotation process of the character conducted in the experimental machine at Basin, Montana, described by Mr. James M. Hyde and Mr. Jesse C. Gibson, in their testimony given in this suit, with which testimony, I understand, you are familiar?

A. Yes.

Q. 19. Please describe the experiments and observations which you have made.

By Mr. Williams: The objections which were noted to the testimony of Jesse C. Gibson, taken at Butte, Montana, and first generally stated after the answer to Q. 15, and then repeated after Q. 19, are here repeated. It is submitted that a defendant may not retain a

machine in secrecy, and refuse the reasonable demands for inspection thereof by opposing counsel, and nevertheless ask the court to pass upon questions involving the processes carried on in such machine, for the purpose of relieving the defendant from a charge of infringement.

A. I spent a number of days at the Basin, Montana, mill of the Butte & Superior Copper Company, the first day being Monday, April 8, 1912, and the last one Sunday, April 14, 1912. During this period I thoroughly examined the entire mill, from the bins where the ore is delivered to the crusher to the final Callow cones, which produce the thickened ore-pulp delivered to the Hyde flotation plant. This flotation apparatus itself, which is a distinct
1556 department of the mill, I saw operated, and myself operated, under different conditions, on different days.

The Hyde apparatus consists of two duplicate or identical portions, arranged along opposite sides of an intermediate platform or alley. One of these portions is used to produce a diluted froth containing as much of the zinc sulfid as can be floated, which as I recall may be upwards of 90 per cent. of the ore-content, and is colloquially termed the "rougher." The other duplicate portion is used to thicken the concentrate froths delivered by the rougher, and is termed the "cleaner." By reason of the identity of these two portions or sections of the plant, their functions may be interchanged, i. e., either side may be used as the "rougher" and the other as the "cleaner." Each duplicate section of the apparatus, extending as stated along one side of the intermediate alley, consists of three units, which are termed "cells," comprising one or more agitator vessels and a flotation box. The first "cell" has three agitator vessels, arranged side by side, and communicating at their lower ends, the first receiving the thickened ore-pulp elevated from the Callow cones, and the last delivering the oiled and aerated pulp to a flotation box. Each agitator vessel is a square wooden box, within which depends a centrally revoluble shaft carrying at its lower end four radial stirring-arms. The ore-pulp fed into the first agitator vessel, initi .y having a temperature of about 3 degrees above the freezing poi : of water, during the time I was at the plant, is warmed to . temperature suf-
1557 ficient to keep the oiling agent fluid and thin, by the injection of steam. The oiling agent, being the "red oil," or impure oleic acid, received in iron drums from Charles T. Perry & Co. of Helena, Montana, is melted out of the drums by rolling them onto a set of steam-coils and by injecting live steam into the drums. The liquid oil is then poured into an iron tank, itself steam-heated, located at the side of but on a higher level than the first agitator vessel. This tank has an outlet leading from its bottom and delivering into the vessel the rate of feed being regulated by a stop-cock in the outlet pipe. The pulp is warmed, oiled and agitated in the first vessel, thence delivered into the second vessel and further agitated, thence into the third vessel and agitated, and is thence delivered through an iron pipe into the side of the flotation-box, which in use is filled with water. The level of the water in this box can be regulated by a

valve and is kept at such height that a thin layer of water at the top, together with the froth of concentrates floating thereon, is continuously delivered over the transverse skimming lip extending across the front end of the box, whence the water and froth fall into a launder.

Adjourned until Friday, May 10, 1912, at 10 A. M., same place.

1558 Washington, D. C., May 10, 1912.

Met pursuant to adjournment. Present, counsel as before.

Direct examination of Eugene A. Byrnes continued:

The pulp minus the first froth is continuously withdrawn from the lower end of the flotation-box to the second "cell" of the "rougher," which is identical with the first cell, except that it employs but two agitator vessels, delivering to a second flotation-box. A second froth is taken off from the second box and delivered to the same launder as the first froth, and the subsiding pulp minus the two froths is lifted and delivered into the single agitator vessel of the third "cell." A final froth is then removed from the (third) flotation-box of this cell, and is delivered into the same launder. The three froths are delivered by the launder to the "cleaner" portion of the plant, which, as stated, is a duplicate of the "rougher." And the water and tailings from the third flotation-box of the "rougher" are discharged as waste. The color of the tailings in this waste gives a very accurate idea of the amount of the metalliferous constituent, blende, which has been removed from the ore. If the "rougher" is operating properly, and the proper amounts of oil and acid are being supplied to the pulp, these tailings are almost white, whereas the original pulp is quite gray, by reason of the blende content. If the oil is fed in excess, it appears in the tailings, associated with
1559 particles of blende, which I should hardly call "granules" on account of their small size, although doubtless several oiled particles adhere together to form the small specks or flocks which I observed when the pulp was overoiled. Excess feed of oil is also at once shown by the character of the froths rising on the flotation-boxes, which then become thinner, less heavy and viscous, and present a shiny, oily appearance, with fewer and larger entangled air-bubbles, instead of innumerable fine bubbles. In the regular operation of the plant, there is no measurement, nor is there any means for measurement, of the amount of oil and acid supplied to the pulp, the feed of both being regulated from time to time to give the best results in the production of heavy froths and clean tailings. The acid, a 25 per cent. solution of sulfuric acid, is fed into the ore-pulp before it is delivered to the "rougher."

The "cleaner" receives the three froths from the "rougher," fed into the first of the three agitator vessels of its first "cell." After successive agitation in these three vessels, the froths, including the water which was discharged with each of them from the rougher cells, is delivered into the corresponding flotation-box, where a very

heavy froth, several inches in thickness rises, and is discharged over the skimming-lip, without any accompanying layer of water. The subsiding liquid is delivered from the bottom of the flotation-box to the first of the two agitators of the second cell, a second froth is taken off in its flotation-box, and the tailings are finally re-
1560 agitated and defrothed in the third cell, the tailings from the third flotation-box of the "cleaner" being then elevated and returned to the first agitator of the second cell of the "rougher."

On my first visit to the plant, I observed the temperatures of the pulp in the three flotation-boxes of the "rougher" inserting a chemical thermometer through the froth in each and downward about one foot into the liquid. The temperature in the first box was 28° C., and in the second and third 27° C., each. I also took the temperatures in the three flotation-boxes of the "cleaner" and found them to be, respectively, 27.5°, 28° and 29° C. Later, at my request, the supply of steam to heat the entering ore-pulp was decreased, so that for a period of about half an hour the temperature in the three "rougher" boxes was 22° C., within a fraction of a degree in each. The froths still remained fairly heavy, and the tailings from the third box light-colored, but containing considerable mineral.

I then had the temperature raised by a supply of more steam, so that the temperature in each box was 24° C., within a fraction. The froths were then quite or fairly heavy, and the tailings quite or fairly clean, though not as good as when the temperature was 27 or 28°. These results were to be expected on account of the fact that the "red oil" used becomes thick and viscous at lower temperatures.

On another day, the "rougher" was entirely emptied, both agitators and flotation-boxes. Operations were then resumed, the pulp entering the first agitator at a temperature of but 3° above
1561 freezing, before the steam was admitted. The pulp was then heated until its temperature in the first flotation-box was 30° C., and about the same in the other two. For the purpose of experiment, I had the iron vessel supplying "red oil" to the first agitator emptied, before beginning this run, and supplied it with cotton-seed oil, not heated. I then ran this oil into the agitator at about three times the rate of feed which was customary with the "red oil," obtaining good froths. The tailings were also quite good, though containing some mineral. I then opened the valve in the oil-discharge pipe to its full capacity, allowing about seven times the normal feed of oil to flow, also separately adding to the agitator a few per cent. proportionate to the cotton-seed oil, of the "red oil," warmed to make it liquid. I then obtained very good heavy froths and very clean tailings, as good, I think, as I saw produced at any time when I was at the mill. It is thus apparent that different oils can be used, in widely different proportions, as I also found in my tests with the Hyde slide apparatus.

Q. 20. Have you any means of stating how long the pulp was agitated in the operations which you conducted and saw conducted at the plant at Basin with the full-sized plant with which you experimented?

By Mr. Williams: Same objection.

A. No, there was no way of determining this. The whole operation is conducted entirely by judgment, that is, by observation of the results obtained, it being necessary to constantly vary condi-
1562 tions to suit the varying amount and character of the ore-pulp received. The operation is continuous, pulp being elevated from the Callow cones, in which the slime-water from the mill proper is thickened, and the froths and tailings being continuously discharged. The levels in the various flotation-boxes require constant judgment to suit the varying feed, one or two operators being constantly employed for this purpose. The agitation was simply continued until the production of froths was satisfactory.

Q. 21. In the spitzkasten with which you experimented in the full-size plant, did you utilize any upcast or upcurrent of water?

By Mr. Williams: Same objection, and it is stipulated that this objection will be continued, without repetition, to all further questions along this line.

A. No. No up-current or other water is supplied to the flotation-boxes, except that contained in the pulp fed into them.

Q. 22. How do carbonates compare with other mineral compounds in stability under the action of acids?

A. Mineral carbonates, for example limestone and rhodochrosite, decompose with extreme facility when reacted upon by mineral acids, such as sulfuric, carbonic acid being a very weak acid.

Q. 23. Do you know of any oil-gas flotation process for the separation of minerals ever having been commercially operated in
1563 this country, other than the operations of Mr. Hyde?

A. I do not.

Q. 24. I ask your attention to the testimony given in this suit by Edward H. Nutter, James M. Hyde, Jesse C. Gibson, and Dr. Charles F. Chandler. Do you find in the testimony of Mr. Nutter and Dr. Chandler, taken in connection with the description of the proce s practiced in the experimental machine at Basin as given by Mr. Hyde and Mr. Gibson, sufficient facts for making a determination of the amount of oleic acid in relation to ore used in the operation of said experimental machine at the time of Mr. Nutter's visit and removal of a sample?

A. Mr. Nutter, in his answer to Q. 15, states that he took a handful of froth concentrates out of "one of the froth-separating boxes from which a concentrate froth was flowing into a launder." It appears from the testimony of Gibson, answer to Q. 20, that there were five of these boxes or "spitzkasten," three in the "rougher" and two in the "cleaner." Nutter testified that he was uncertain as to their number, but on his sketch has shown seven, lettered *a* to *g*. He says that he took the handful of froth from "box *f*," or the sixth one in order. This is evidently a mistake, as witness Hyde also testifies that there were but five of these frothing boxes or spitzkasten, and so indicates on his "Sketch of Experimental Machine" in evidence. Nutter further testifies that the pulp under treatment "was being brought into the plant by workmen in buckets and

1564 wheel-barrows and fed into, I think, mixer No. 1." On his drawing, he shows ten mixers, the ninth of which delivers to froth box *f*. As mixer 1 was, according to his sketch, at the other end of the plant from mixer 9, and as they were in two different units, his testimony shows nothing as to the kind or amount of the pulp, ore, oil, acid, or any other material in mixer 9? Nutter further testifies that, "As I recollect it, the ore was supplied to the flotation plant as a wet ore pulp or mud," evidently referring to the material brought in wheel-barrows and possibly fed into mixer 1. He states that he did not see oil being supplied to the material treated. From this random handful of concentrates from an alleged sixth frothing box, which did not exist, Professor Chandler draws certain conclusions as to the percentage of oil which was employed by the defendant, figuring it as "0.16 per cent. of oleic acid on the ore." This conclusion, however, is based on pure speculation, and is a guess. In making his calculations, he "assumed that that concentrate represented one-third of the original ore"; and he also assumed "one-third as much more for * * * loss on the tailings," here referring to oil carried into the tailings. There is no warrant whatever for these assumptions, so far as I can determine from the testimony of any witness. Gibson testifies that at the time Mr. Nutter entered the plant "The mill was down * * * and we are treating the concentrates made on the vanners, feeding it into the flotation machine by buckets"; that these materials were not
1565 an average grade of concentrates, whether higher or lower than the regular ore pulp, he could not say; and that the sample procured by Mr. Nutter was not a representative one of the product of the machine. The defendant, Mr. Hyde, also testifies, in R. D. Q. 135, as to the material being treated at the time Mr. Nutter entered the plant, that—

"At that time, the machine was running upon the accumulated low-grade concentrates which had been produced upon the vanners. This was one of those numerous occasions which have previously been referred to upon which the main body of the mill was shut down, and the ordinary feed was not available for the experimental machine."

As Mr. Nutter made no observations whatever at the time of his visit as to the oil supplied to the material being treated; as the amount of oil added was never weighed or measured, and was variable according to conditions and the judgment of the operator (Gibson, Q. 13-Q. 15); as the material being treated at the time of Mr. Nutter's visit was vanner concentrates of unknown composition and grade, unknown ratio to the ore or ore pulp ordinarily treated, and not representative of the ordinary pulp-feed; as these concentrates were simply dumped into mixer 1 by buckets, in an irregular and haphazard manner; and as the amount of mineral and oil which went into the tailings was unknown, I am clearly of the opinion that no legitimate conclusion whatever can be drawn from the
1566 percentage of oleic acid in the handful of froth taken away by Mr. Nutter, as to the ratio or percentage of oil relative to

ore employed by the defendant, or as to whether or not it is within the limits specified in the patent in suit.

Q. 25. Will you state any instances with which you are familiar, whether in the metallurgical art or elsewhere, in which agitation of a substance is utilized as a means of aeration or as a means of introducing some other gas into such substance?

A. Aeration of a liquid by agitating it in the presence of atmospheric air and beating the air into and through it in the form of fine bubbles, to produce a froth, is an everyday operation with which we are all familiar. I need only instance such domestic operations as the beating of eggs and the whipping of cream, or the soda-fountain operation of producing "milk-shake." It is customary in various arts to thus aerate liquid. For example, it is common to aerate soap while in the molten or liquid condition, to produce a material which will be light and float when solid. An agitator for this purpose, of the general type employed by defendant, is shown in an old book on the manufacture of soaps which I happen to have at hand. I refer to "A Treatise on Chemistry Applied to the Manufacture of Soap and Candles," by Campbell Morfit, copyrighted in the year 1856 and published in Philadelphia in 1860, by Henry Carey Baird. See the article on pages 271-272, "Flotant Soaps," and the accompanying figures 54 and 55. It is common in
1567 the production of butter to churn and beat air into the milk, the air diffused throughout it acting to throw down the curd and separate it from the butter. I refer, for example, to U. S. patent No. 373,113, granted November 15, 1887, to H. J. Wagner, page 2, lines 6-30. Instances of these methods might be indefinitely multiplied.

It is stipulated that the book by Campbell Morfit referred to by the witness was published and circulated during the year 1860.

Pages 271 and 272 of the book referred to by the witness are introduced in evidence, and marked by the Examiner "Defendant's Exhibit Extract from 'Treatise on Chemistry Applied to the Manufacture of Soap and Candles.'"

The patent referred to by the witness in the foregoing answer is introduced in evidence, and marked by the Examiner "Defendant's Exhibit Wagner Patent 373,113."

Adjourned until Monday, May 13, 1912, at 10 A. M., same place.

1568 Washington, D. C., May 13, 1912.

Met pursuant to adjournment.

Present: Counsel as before.

Direct examination of Eugene A. Byrnes continued:

Printed Patent Office copies of the patents referred to by the witness are introduced in evidence, and respectively designated by the Examiner with the words "Defendant's Exhibit," and the title of the patents, as follows:

Bradford Patent No. 345,951,

Everson Patent No. 348,157,
Hockley Patent No. 466,753,
Rouse Patent No. 469,599,
Hebron & Everson Patent No. 471,174,
F. E. Elmore Patent No. 653,340,
F. E. Elmore Patent No. 676,679,
A. S. Elmore Patent No. 689,070,
A. S. Elmore Patent No. 692,643,
Stoveken Patent No. 729,805,
Delprat Patent No. 735,071,
Glogner Patent No. 736,381,
Good Patent No. 745,960,
Delprat Patent No. 768,035,
Kendall Patent No. 771,075,
Potter Patent No. 776,145,
Cattermole Patent No. 777,273,
Cattermole, Sulman & Picard Patent No. 777,274,
1569 Cattermole, Sulman & Picard Patent No. 788,247,
Sulman and Picard Patent No. 793,808.
Schwarz Patent No. 807,501,
Schwarz Patent No. 807,503,
Kirby Patent No. 809,959,
Sulman Patent No. 835,143,
Sulman, Picard and Ballot Patent No. 835,479,
Kirby Patent No. 838,626,
Sulman, Picard and Ballot Patent No. 879,985,
Hyde Patent No. 1,022,085.
British Patent to Lake (Froment) No. 12,778, of 1902.

It is stipulated that this Lake (Froment) British patent was sealed on August 18, 1903.

By Mr. Williams: Counsel for defendant having agreed to file an amendment to the answer of defendant, including the prior patent above offered in evidence, patents Nos. 793,808 and 809,959, and the applications for patents not issued before the application for the patent in suit, subject to the condition heretofore stated, the objection of incompetency is now made, but will be withdrawn upon the filing of such amendment.

Certified copies of the applications for and proceedings in the United States Patent Office relating to United States patents Nos 788,247, 793,808, 807,501, 807,503, 809,959, 838,626 and 835,120 are introduced in evidence, and marked by the Examiner as follows:

1570 "Certified Copy of File-Wrapper and Contents of Cattermole, Sulman & Kirkpatrick-Picard Patent No. 788,247."

"Certified Copy of File-Wrapper and Contents of Sulman & Kirkpatrick-Picard Patent No. 793,808."

"Certified Copy of File-Wrapper and Contents of Schwarz Patent No. 807,501."

"Certified Copy of File-Wrapper and Contents of Schwarz Patent No. 807,503."

"Certified Copy of File-Wrapper and Contents of Kirby Patent No. 809,959."

"Certified Copy of File-Wrapper and Contents of Kirby Patent No. 838,626."

"Certified Copy of File-Wrapper and Contents of Patent in Suit, No. 835,120."

By Mr. Williams: The objection of incompetency is now made as to the file-records of patents Nos. 778,247, 793,808, 807,501, 807,503, but will be withdrawn upon the filing of an amendment to the answer of the defendant, as above stated. It is to be noted, however, that statements made during the prosecution of other applications for patents than for the patent in suit and appearing in the above exhibits, are objected to as irrelevant and immaterial to the issues herein, and incompetent to prove any statements that may be made in such correspondence.

1571 One of the two duplicate slide machines referred to and used by the witness J. M. Hyde and E. A. Byrnes is introduced in evidence, and marked by the Examiner:

"Defendant's Exhibit Slide Machine."

The apparatus referred to by the witness E. A. Byrnes as having been made in accordance with Figure 1 of the drawing of the patent in suit is introduced in evidence, and marked by the Examiner:

"Defendant's Exhibit Apparatus of Patent in Suit."

The apparatus referred to by the witness E. A. Byrnes as having been made in accordance with Figure 1 of the drawing of Sulman and Kirkpatrick-Picard patent No. 793,808 is introduced in evidence, and marked by the Examiner:

"Defendant's Exhibit Apparatus of Patent No. 793,808."

It is stipulated by and between the parties hereto that the testimony of the witness James M. Hyde and Eugene A. Byrnes regarding the results of assays made by W. A. Hocking of Butte, Montana, and reported by him to said witnesses shall have the same force and effect as if said W. A. Hocking had been examined as a witness in this suit and had testified to the same effect as said witnesses in regard to said assays, the right of cross-examination being waived; but it is understood and provided that this stipulation does not waive the objection interposed by complainant following the answer of the witness E. A. Byrnes to question 17.

1572 It is stipulated that copies of the documents which were marked for identification during the taking of the deposition of the defendant, James M. Hyde, may be offered and used in evidence in place of the original documents, subject to the production of the originals upon reasonable demand.

Direct examination closed.

Cross-examination by Mr. Williams de bene esse, not waiving the objections and notices heretofore stated and given:

X Q. 26. At the time that you were Principal Examiner of the Division of Metallurgy and Electro-chemistry in the United States

Patent Office, how many Principal Examiners were there in the Patent Office?

A. The number varied during this ten-year period, increasing, in a general way, from, say, twenty-five to thirty-five.

X Q. 27. Were any of the patents to which you have referred in your testimony examined in the Division of Metallurgy and Electrochemistry?

A. Fourteen of the nineteen U. S. patents to which I have referred were granted since my resignation from the examining corps, and I have not examined the file-records to determine in what division they were considered. I do know the gas-flotation processes of the character in suit, so far as the art had been developed at the time of my resignation, were at least largely examined in the division of
1573 Metallurgy and Electrochemistry. I remember personally acting on several applications of this class, including, I believe, applications of Charles B. Potter and Guillaume D. Delprat, grantees of two of the patents referred to by me. The art of flotation by a chemically-generated gas, as evolved by the action of mineral acids upon ores of the Australian "Broken Hill" type, was being actively developed during the latter part of my term as Examiner.

X Q. 28. I have examined the original files in the Patent Office of the patent to Delprat No. 768,035 and the patent to Potter No. 776,145, these being the patents to these grantees referred to by you, and have not found your signature upon any action in the applications for these patents. I found that they were classified in Class 83, Mills, ore and coal washers. I note from the patents that the application for the Potter patent was filed January 14, 1902, and the application for the Delprat patent was filed January 2, 1903. Are you still of the opinion that you acted upon the applications for these patents?

A. I have not stated that I acted upon these particular applications, for this is an impossibility, since I resigned as Examiner, as stated in my answer to Q. 2, in November, 1901. What I did state was that among the applications on gas-flotation by the use of chemically-generated gas which I examined during the latter part of my term were, as I recollect, applications filed by these same
1574 inventors. I have a very definite recollection of the fact that applications on processes of this type were considered by me, and I also remember that these two inventors were among the earliest in this particular field. My interest in this subject was continued by the fact that subsequent to my resignation, I had clients who were working in the mineral-flotation art, including one who was operating on zinc sulfid ores, by a method which he considered an improvement upon that of Potter and Delprat, and another who was working on the flotation of sulfid ores by the film or surface-tension principle.

The classification of the Patent Office is constantly undergoing modification, and as the art in various lines grows, new divisions are established, and many rearrangements are made in the classes handled in any particular division. For example, the very large class of "Amalgamators," which was in my charge for some years, was sub-

sequently transferred to the class which you mention, No. 83, "Mills." In view of the statement that the specified Potter and Delprat patents are now in this class, it is quite likely that there has been a further transfer of art from Division 3, the one which I had in charge, to Division 25, including "Mills." As to this, however, I am not informed, not having examined the file-records.

X Q. 29. I note that the applications for the patents to Bradford, Everson, Hockley, Rouse, Hebron and Everson, and the four patents to Elmore were pending while you were in the Patent Office. Did you act as Examiner on any of these applications? I note that
1575 you, in your testimony, referred to only two of these Elmore patents, although four were introduced in evidence.

A. The Bradford and Everson patents were granted in 1886, before I was Examiner in the Division of Metallurgy.

I do not recall acting on the Hockley, Rouse, Hebron & Everson or Elmore patents, and it is quite possible that these were examined under the class of "Mills," as the line of demarkation between Divisions 3 and 25, handling "Metallurgy" and "Mills," was not entirely definite. As a rule, where ore-treatment involved some chemical reaction, such as that of acids on the constituents of the ore, the application was assigned to "Metallurgy"; where the separation was purely mechanical, to "Mills." The Hockley patent was referred to by me as a disclosure of the well known fact that finely-divided gold and silver will float on water, illustrating the principle of surface-tension flotation. There were many patents and applications for the recovery of "float gold" in the class of "Amalgamators," before I transferred it to "Mills." I do not recall whether or not this patent was one of them. Some patents and applications for the recovery of "float gold," involving electrochemical treatment, were retained in Division 3 when I established the present class of "Electrochemistry," which has a sub-class, "Ores," and the line between Divisions 3 and 25, on electrical amalgamators was very unsettled at the time I resigned.

1576 The Rouse patent, while describing a method of floating mineral as a froth by aeration, does not specify the use of acid, and quite likely was examined in Division 25, although as to this I have no recollection or knowledge.

The Hebron and Everson patent was cited by me as the one probably referred to in the Cattermole, Sulman & Kirkpatrick-Picard patent 788,247, as describing the mechanical flotation of mineral by particles of wood or other light material. It was quite likely examined in Division 25, under "Mills," although I do not know as to this.

The four Elmore patents offered in evidence relate to the flotation of mineral by oil per se, rather than gas. I cited two of them as illustrations of the preferential affinity of oil for mineral; and one, No. 689,070, as an illustration of the use of a very small amount of acid to increase the preferential affinity of oil for mineral, this being especially interesting on account of the fact that the corresponding British patent was the basis of a suit against the present plaintiff on this feature. I do not know where these Elmore patents are classified,

but the flotation processes described therein do not rely on aeration or the evolution of a gas.

X Q. 30. What explanation can you give of the phenomenon of the preferential affinity of oils for metalliferous constituents of ores, especially sulfids?

A. I take it that this is a matter of fact, and not of theory. It is a phenomenon, the knowledge of which is supposed to date back
1577 at least as far as Herodotus.

X Q. 31. What e planation can you give of the action of acids in increasng the preferential affinity of oils for metalliferous minerals in an ore pulp?

A. I have no theory to account for this action. Possibly the acid slightly cleans the surface of the sulfid. Possibly the acid itself has a preferential affinity for the gangue. Acidulated water seems to displace oil from the gangue, when mineral is present, as is stated in the Everson patent, and as I ascertained by experiments.

X Q. 32. You have spoken of the fact that bubbles of air or gas in an ore-pulp attach themselves to greased metalliferous particles. To what do you attribute this phenomenon?

A. To the affinity of air or gas for grease.

X Q. 33. When you say that the function of the air or gas bubbles is identical, whether they be shaken or beaten in, injected in streams, chemically or electrolytically generated in the pulp, produced by increasing and then diminishing the pressure on the pulp surface, produced by creating a partial vacuum over the pulp surface, or produced by boiling the pulp, do you mean that the action of the air or gas-bubbles is identical in all these cases?

A. I do. I mean that the same amount of air or gas, distributed in the same way in contact with the same amount, kind and size of oiled mineral particles, will have precisely the same flotative
1578 effect, whatever the source of said air or gas, and however it be introduced or distributed. I, of course, do not mean to say that the same amount can be introduced and the same distribution effected by all these methods, or that air could be "chemically or electrolytically generated in the pulp," or "produced by boiling the pulp."

X Q. 34. Do you understand this phenomenon to be a surface-tension phenomenon?

A. To a certain extent, yes?

X Q. 35. Please explain more fully.

A. Froment, in his patent 12,778, of 1902, speaks of his observation that when natural sulfids are reduced to powder and are moistened by a fatty substance, and when a gas of any kind is liberated in the mass, the bubbles of the gas become covered with an envelope of sulfid. He refers to these coated bubbles as "metallic spherules." He also speaks of the fact that the metallic spherules, pressed one against the other, will become grouped in a magma clearly separated from the rest of the liquid.

The production and existence of bubbles is a phenomenon of surface-tension, and the relation and form, in a froth, of bubbles pressed together, is a very complicated matter, the mathematics of which has

been considered by very learned men. When the mutual relations of solids, liquids and gases are involved, and the surface-tensions between them, the question becomes an extremely difficult one.

X Q. 36. In commenting upon the Bradford patent, in which there is a disclosure of flotation of particles on water by reason of
1579 air-films, you refer to the greased needle flotation phenomenon. Are these two phenomena attributable to the same cause, and if so, what is it?

A. In general, yes, specifically, no. The Bradford patent refers to the flotation of unoiled minerals, finely-divided, I have referred to the fact that when such particles are coated with a film of absorbed, or adherent air, they may float on water, because not wetted, or only slightly wetted thereby, lying on the surface of the water as on an actual skin or thin membrane, slightly depressed beneath them. A film of oil or grease on the surface of a sewing-needle tends to prevent actual contact of the needle with water, or its wetting with water, when it is laid gently on the surface of water, and thereby to bring into play the phenomenon of support by surface-tension. Doubtless in this case, also, there is a film of air surrounding the film of oil or grease.

X Q. 37. In your discussion of the Sulman & Picard patent No. 793,808, you refer to the Froment, Potter and Delprat patents, in connection with a statement as to "the known method of chemically generating a gas to float the oiled particles." Do Potter and Delprat deal with oiled particles?

A. No. My reference was intended to be to the chemical generation of a gas, for the purpose of floating oiled particles, by the reaction of acid on carbonates or sulfids, as practiced by the patentees specified.

X Q. 38. To what do you attribute the flotation of unoiled
1580 particles of metalliferous matter in an ore-pulp, as disclosed by Potter and Delprat?

A. Delprat says:

"This process is readily carried out at ordinary temperatures, and depends upon the ore particles being attacked by the acid to form a gas. Each ore particle so attacked will have a bubble or bubbles of gas adhering to it, by means of which it will be floated and can be skimmed or floated off to solution."

Potter says:

"Heat being applied, the effect of the acidulated solution becomes apparent by the bubbling up and gathering on the surface of the fluid of the metallic concentrates in the form of a pasty mass."

Potter's claim 3 says:

"forming a suitable solution containing sulfuric acid to react on the soluble sulfids present to form bubbles of sulphuretted hydrogen on the ore particles and thereby raise them to the surface."

X Q. 39. I assume, therefore, that you accept the statements of these patentees and endorse them. Are these surface-tension phenomena?

A. Necessarily so, since solid particles, liquid and bubbles of gas, are in mutual contact. The surface-tension phenomena are, however, much more complicated than the simple flotation of a single
1581 aerated or oiled particle lying on the surface of the liquid.

X Q. 40. Now dealing with the attachment of a bubble of gas to a particle of metalliferous mineral in the body of an ore-pulp, is this a surface-tension phenomena?

A. Yes.

X Q. 41. In the case of the Potter and Delprat processes, do you understand that there is any moving together, followed by attachment, of the bubble of gas and the mineral particle?

A. If I understand the question, no, since the attached bubble of gas is generated in situ by the reaction of the acid on the particle itself. Of course some bubbles of the gas generated might shift to another particle or particles, or several particles might adhere to one bubble.

X Q. 42. Now assume oiled metalliferous particles in a body of ore-pulp, and bubbles of air or gas in this body of ore pulp, what action takes place?

A. The question is too vague to admit of a definite answer, since it does not state the relation of the oiled particles and bubbles.

X Q. 43. What would be necessary in order to bring about an interaction between the oiled metalliferous particles and the bubbles of air or gas, under the conditions stated in the last question?

A. Assuming that "interaction" here includes adhesion, I should say that contact between the oiled particles and bubbles would be the first essential.

X Q. 44. In your description of experiment No. 4 of your
1582 seven numbered experiments in connection with the Froment patent, you say you added a few drops of sulfuric acid. How much sulfuric acid did you add and of what strength?

A. I think about five drops of concentrated acid.

X Q. 45. Did you make any measurements that would indicate the amount of these five drops in weight or otherwise?

A. Only by counting them as they dropped from the burette containing the acid.

X Q. 46. You also say that the mixture was gently heated. To what temperature was it heated?

A. It was heated by placing it in the warm water running from the spigot at the sink. I did not take the temperature by a thermometer.

X Q. 47. In your experiment 5, you say you added one drop of olive oil. Can you give the weight of this drop of oil or otherwise describe it so that the experiment may be duplicated?

A. I did not weigh this drop, or one like it. The same amount can be obtained by dropping the oil from a burette such as I used to transfer the oil from its bottle to the test tube. This burette was one of the usual kind, having a cylindrical bore about one foot long, designed to deliver one cubic centimeter, and graduated in tenths of a cubic centimeter.

X Q. 48. In your experiment 6, you again say that the "whole

was gently heated." In what manner and to what temperature was this heating accomplished?

A. By warm water from the spigot, as before, to a temperature not measured by a thermometer.

1583 X Q. 49. Again, in experiment 7, you state "a few drops of sulfuric acid." How many, of what strength and of what weight?

A. About five drops of concentrated acid, as delivered by the ordinary fifty cc. burette having a glass stop-cock.

X Q. 50. Was this same burette used for dropping sulfuric acid wherever used in these seven experiments?

A. Yes.

X Q. 51. In carrying out a test of a process of separation alleged by you to correspond to that of the Kirby patent, No. 809,959, you say you agitated the mixture in the slide machine which you designate the "Hyde Slide Machine." At what speed did you rotate the agitator?

A. About sixteen hundred revolutions a minute.

X Q. 52. Did you measure this speed of rotation?

A. Yes. That is, I measured the speed of the electric motor while driving it, by a tachometer, and employed pulleys on the motor and agitator shafts of practically the same diameter.

X Q. 53. In your description of the test in which you allege you carried out the process of the Schwarz patents 807,501 and 807,503, you mention agitation but do not give the speed of rotation of the agitator shaft. What was this speed?

A. The same as before, about sixteen hundred revolutions per minute.

X Q. 54. Is this also true of the test next described by you, in which you alleged that you carried out the operations of the Everson patent 348,157?

1584 A. Yes.

X Q. 55. In your description of tests of the apparatus which is in evidence as "Defendant's Exhibit Apparatus of Patent No. 793,808," you say that the coil of pipe was rapidly rotated. At what speed was it rotated?

A. I ran this apparatus both in Butte, Montana, and in Washington, D. C., in each case driving it by a belt from the stepped cone of an engine lathe. I shifted the belt from step to step until I obtained as high a speed as possible, without the belt slipping or throwing off. I had no means at hand at either place for measuring the speed, but judge that it was several hundred revolutions per minute.

X Q. 56. In certain tests described by you as under the process of the Froment British patent, using the "Hyde Slide Apparatus," you speak of brief agitation, but do not give the period of agitation or the speed of rotation of the agitator shaft. Please supply these particulars as nearly as possible?

A. In general, the first agitation was for a period of thirty seconds, and the subsequent agitations about ten to twenty seconds each. The speed of the agitator was about sixteen hundred revolutions per minute.

X Q. 57. You next describe tests of an apparatus introduced in evidence as "Defendant's Exhibit Apparatus of Patent in Suit," and say that the cone mixer was rapidly rotated. At what speed was it rotated?

A. It was driven by the same electric motor as that used with the Hyde slide machine, having a speed of sixteen hundred per
1585 minute. The pulleys on the shaft of the motor and cone agitator were about the same size. I ran the cone at as high a speed as I could without the quarter-inch round leather belt slipping, increasing the tension slightly on the belt as the agitator ran more heavily. There was some tendency for the cone to clog with ore, and also for ore to work into the step at the lower end of the agitator shaft and increase the frictional resistance. This step ground out considerable in use, however, so that the shaft did not bind so much in the later work.

X Q. 58. I take it that you did not measure the speed of rotation during this test.

A. No, not that of the cone shaft. I could not keep the tachometer on its upper end, on account of its lateral vibration. The standard carrying the bearings for the upper end of the shaft was not sufficiently inflexible to hold the bearings rigidly in place.

X Q. 59. Did you measure the speed of the motor while it was subjected to the load of the work of rotating this cone-agitator during the agitation for ten minutes or during any other actual use of this apparatus?

A. Yes. The motor which I used in my laboratory was a single-phase one of the constant-speed type. I allowed it to run at its normal speed, sixteen hundred revolutions per minute, regardless of the load, decreasing the tension on the belt if necessary to enable it to keep up the speed.

Adjourned until Tuesday, May 14, 1912, ten A. M., same place.

1586 Washington, D. C., May 14, 1912.

Met pursuant to adjournment. Present, counsel as before.

Cross-examination of Eugene A. Byrnes continued:

X Q. 60. You have made the positive statement that the slide machine used by you in your tests was "designed in part by the defendant." What is the source of your knowledge of this fact?

A. The defendant.

By Mr. Williams: Notice is given of a motion to strike out the part above quoted of the answer to question 4 as hearsay and incompetent.

X Q. 61. You have introduced into this record for the first time the name of the Black Rock mine of the Butte & Superior Copper Company, and have apparently confined your investigations and

tests relative to the ores used by defendant to this mine and its product. Please state your reason for doing so.

A. The alleged infringement, as I understand it, is the use of the process in suit for the treatment of the ore from this mine. I was therefore especially interested in determining whether the processes of the prior art were adapted for the treatment of this ore, which I found to be the case. Furthermore, this ore is one which I should a priori judge to be a proper one for treatment by the various oil-gas flotation processes set forth in the prior art, since its important metalliferous constituent, to the extent of thirty per cent., is
1587 zinc sulfid, and since it invariably contains a carbonate easily decomposable by sulfuric acid to evolve a gas.

X Q. 62. In your answer to Q. 23 you say that you do not know of any oil-gas flotation process for the separation of minerals ever having been commercially operated in this country, other than the operation of the defendant, Mr. Hyde. Please explain what you intended to include by "oil-gas flotation process." You will note that I have combined the question and answer referred to in my question.

A. By the expression "oil-gas flotation process," I understood a process for the flotation of the metalliferous constituents in ore, based upon the preferential affinity of oil for this constituent and of gas for the oil, that is, one in which the mineral particles are oiled and are then floated by attached bubbles or films of air or gas.

X Q. 63. What patents referred to by you did you intend to include within this definitive term?

A. My answer in question did not relate to the prior art as set forth in the patents cited in my answer to Q. 4, but to the commercial operation of a process of this type.

X Q. 64. Described in what patents?

A. Whether described in any patent, or in none.

X Q. 65. What patents referred to by you describe oil-gas flotation processes?

A. I should say that the following patents referred to by me describe oil-gas flotation processes, that is, processes in which
1588 the mineral particles are oiled and then floated by attached bubbles or films of air or gas:

348,157, to Everson.
736,381, to Glogner.
745,960, to Good.
788,247, to Cattermole & Kirkpatrick-Picard.
793,808, to Sulman & Kirkpatrick-Picard.
807,501, to Schwarz.
807,503, to Schwarz.
809,959, to Kirby.
838,626, to Kirby.
British 12,778 of 1902 to Froment.

Furthermore, as I have heretofore stated, the amounts of oil specified in the Cattermole patent 777,273 and in the patent in suit overlap each other, or may be the same as applied to many ores, and since precisely the same cone agitator is used in both, the two processes

may become identical. In other words, while Cattermole describes his process as one of agglomerating the oiled mineral particles into heavy granules which sink, and while the patentees in suit describe their process as one of aerating and floating oiled mineral particles, it is obvious that when the same amount of oil is used on the same ore, with the same agitator, the same conditions will give the same result in both cases, so that the Cattermole process will float the same amount of mineral as the process in suit. And in view of my experiments in which I used amounts of various oils as great or greater than the percentages specified by Cattermole, when based on
1589 the weight of metalliferous mineral matter present in the "Black Rock" ore, with a more efficient agitator than that shown by Cattermole and adopted by the patentees in suit, and obtained a very high recovery by aeration and flotation of the oiled mineral, I should say that the process of this Cattermole patent itself, at least as applied to the "Black Rock" ore and with the kinds of oil used by me, is one of oil-gas flotation. And this opinion would equally apply to the process of the Cattermole, Sulman & Kirkpatrick-Picard patent 777,274.

X Q. 66. Do you know of any commercial use in the United States of the treatment of ores of the processes disclosed in any of the patents referred to by you in your testimony and not included in the answer which you have just given?

A. I think the processes of the Elmore patents 676,679 and 689,070, have been commercially tested in this country, though I cannot say positively as to this. I am quite sure that processes of the type described in the Delprat patent 735,071 and Potter patent 746,145 have been used in this country, although I do not just now recall where or to what extent, aside from the method of this type used by my own client, heretofore referred to. I think the process of the Kirby patents 809,959 and 838,626 has been operated in this country or in Canada; but whether or not to an extent which would be termed "commercial" I do not know, and this is an impression rather than a definite recollection.

In this answer, and that to X Q. 65, I of course do not in-
1590 clude the process patented to the defendant, and in use by him at Basin, Montana.

X Q. 67. Do you know of any present use in the United States, commercially, in the treatment of ores, of the processes of the Elmore, Delprat, Potter or Kirby patents?

A. I have at present no positive recollection as to such use.

X Q. 68. In describing the defendant's apparatus as examined and tested by you at Basin, Montana, during April of the present year, you say that the pulp is delivered through an iron pipe from the third agitation vessel of the first cell to the flotation-box. Please describe this iron pipe as to internal diameter, length and position.

A. This pipe was of wrought iron, in three pieces joined by two ells. I did not measure its internal diameter, but judge that it was about 4 inches. It extended from the end of the third agitation vessel horizontally outward perhaps 2 feet, where it was united by an ell at right angles to another horizontal piece extending forward

a few feet to the side of the flotation-box. The end of this latter piece was united by an ell to a third horizontal piece extending at right angles to the second and into and through the side of the flotation-box, near its top and back, as viewed from the platform extending along the front of this box.

X Q. 69. At what part of the agitation vessel did this pipe emerge therefrom?

A. From the end near the bottom, just above the floor of the vessel.

1591 X Q. 70. Was a similar pipe used for connecting each of the other flotation-boxes with its agitation vessel?

A. Yes.

X Q. 71. Please describe the construction of the flotation-box which was present in this apparatus.

A. This box had vertical rear and side walls. Its front wall inclined outward and upward at an angle of about 30° to the rear wall, which it nearly joined at the bottom. It was built of heavy plank, was entirely open at the top, and had at its front edge, adjacent to the platform a depressed portion or lip, over which the froth with some water was discharged into the launder just below.

X Q. 72. You say that the level of the water in the first flotation-box can be regulated by a valve. Where is this valve located and how did it effect this regulation?

A. A large iron pipe, probably 4 inches in internal diameter, extended laterally and thence upwardly from the lower end of the flotation-box, delivering into the agitation vessel, or first agitation vessel, of the next "cell." In the lower horizontal portion of this pipe was a revoluble through-plug, from which an operating shaft extended upward to a point near the top of the flotation-box, where it had a handle. By turning this plug or cock the outflow through the pipe could be regulated. However, as the floors of the agitation vessels were at a higher level than the surface of the water in the flotation-boxes, it was necessary to lift the pulp discharged from the bottom of each flotation-box to the next vessel. For this

1592 purpose a stream of compressed air, regulated by a valve, was admitted to this pipe at the union of its horizontal and vertical portions. Increasing the supply of air increased the rate of discharge from the flotation-box, and correspondingly lowered the level therein.

X 9. 73. At what part of the first agitation vessel of the next cell did this pipe enter it?

A. The side, a short distance above the bottom.

X Q. 74. Near the middle or near an end of the side?

A. I think near the middle.

X Q. 75. Does the description which you have given of the connection from the bottom of a flotation-box to the first agitation vessel of the next cell apply equally to all of the connections of this character in this apparatus?

A. Yes.

X Q. 76. You have described the agitator as having four radial stirring arms. Did these arms have inclined faces, as shown in the

Hyde patent No. 1,022,085, or vertical faces, as in "Defendant's Exhibit Slide Machine"?

A. Vertical faces.

X Q. 77. In describing your first test with cotton-seed oil in this apparatus, you say you ran the cotton-seed oil into the agitator at about three times the rate of speed which was customary with the red oil. How did you determine that this was the rate of feed?

A. By measuring the two rates.

X Q. 78. And how did you measure them?

A. By noting the amount discharged into a glass cylinder
1593 graduated in cubic centimeters, in a noted time, fifteen or thirty seconds.

X Q. 79. What did you thus determine as the rate of speed in each instance?

A. While I can hardly say that there is any "normal" rate of feed for the red oil, I did determine this rate on different occasions, finding it to be, in one test, about 100 cubic centimeters per minute, and in another about 120. In using cotton-seed oil, I first ran at 300 cubic centimeters per minute, which I denominated "three times the rate of feed which was customary with the red oil." I afterward ran with the valve open to its full limit, then discharging 735 cubic centimeters per minute, to which I added, in a separate stream, 30 cubic centimeters of red oil per minute.

X Q. 80. Did you measure the rate of feed or the state of dilution of the pulp which was fed to the first agitation vessel?

A. No.

X Q. 81. Did you measure the amount of concentrates or the amount of tailings discharged from the apparatus in any given time?

A. No. Both the feed of pulp and discharge of froths and tailings was quite variable, necessitating constant regulation of conditions. The operations being continuous, I did not attempt to interrupt them to determine if there was any average rate of supply or discharge of froths and tailings.

X Q. 82. What would be your estimate of the hourly or daily capacity of the apparatus expressed in any terms?

1594 A. I could not give even an approximate figure.

X Q. 83. What were the general dimensions of each agitation vessel?

A. Inside measurements, about 28 inches square and four feet deep.

X Q. 84. What were the general dimensions of each flotation box?

A. About three feet wide, five feet from front to rear at the top, and seven feet deep.

X Q. 85. Please describe the connection from the third flotation box of the cleaner to the first agitator of the second cell of the rougher?

A. The tailings were lifted through a vertical iron pipe, by a centrifugal pump, to a point at such height that they could be run by a launder into the agitation vessel.

X Q. 86. Where did this launder enter the agitation vessel?

A. It discharged into its open top.

X Q. 87. Did you measure the speed of rotation of the agitator blade of this apparatus?

A. No.

X Q. 88. You are familiar, are you not, with a publication in the Engineering & Mining Journal, of November 15, 1890, relative to the Everson process?

A. Yes, assuming that you refer to the article on page 581.

Cross-examination closed.

Deposition closed.

EUGENE A. BYRNES.

1595 It is stipulated and agreed that the further taking of testimony upon behalf of defendant may be and is adjourned to such time and place and before such examiner as the court may direct or as counsel herein might agree upon.

Notary's Certificate.

United States District Court, District of Montana.

In Equity.

No. 1076.

MINERALS SEPARATION, LIMITED, and MINERALS SEPARATION AMERICAN SYNDICATE, LIMITED, Complainants,

vs.

JAMES M. HYDE, Defendant.

DISTRICT OF COLUMBIA,
City of Washington, ss:

I, Joseph H. Blackwood, a Notary Public, Special Examiner by consent of counsel in the above-entitled cause, hereby certify that the foregoing depositions of James M. Hyde and Eugene A. Byrnes were taken before me directly on the typewriter after the witnesses had been duly sworn to testify the truth, the whole truth and nothing but the truth, and when completed were read over by the said witnesses and signed by them in my presence; that the said depositions were taken, pursuant to notice and agreement between counsel, at the offices of Byrnes, Townsend & Brickenstein, 918 F St., N. W., Washington, D. C., commencing on Wednesday, April 24, 1596 1912, and continuing on April 25th, 26th, 29th, May 1st, 2nd, 3rd, 6th, 8th, 9th, 10th, 13th and 14th; that the complainants were represented by Henry D. Williams and the defendant was represented by J. Bruce Kremer and Walter A. Scott; that the several exhibits therein cited were offered in evidence and were marked as therein noted; that I am not of counsel for either party

to this cause, nor related by blood or marriage to any member of either of the complainant corporations or the defendant, and that I am not interested directly or indirectly in the matter in controversy.

In testimony whereof I have hereunto set my hand this 1st day of June, 1912.

JOSEPH H. BLACKWOOD,
Notary Public, District of Columbia.

1597 *Order.*

At a Stated Term of the United States District Court in and for the District of Montana, Held at the Court-house in Butte, Montana, this 6th Day of July, 1912.

Present: Hon. George M. Bourquin, Judge.

In Equity.

No. 1076.

MINERALS SEPARATION, LIMITED, and MINERALS SEPARATION AMERICAN SYNDICATE, LIMITED, Complainants,

vs.

JAMES M. HYDE, Defendant.

Order.

On motion of defendant, and on reading and filing the stipulation hereto annexed, and with the consent of the complainants, it is

Ordered, that a commission be issued to this cause out of this Court, directed to Joseph Phillips Crawley, of 9 Bishopsgate, London, England, a Notary Public, residing in London, England, to examine the following named persons under oath as witnesses herein, viz.:

Henry Livingstone Sulman, Hugh Fitzalis Kirkpatrick-Picard, John Ballot, D. P. Mitchell, Francis E. Elmore, Alexander S. Elmore, Herbert C. Hoover, Theodore J. Hoover, and such other witnesses as defendant shall desire to examine. It is further

Ordered, that the examination above provided for shall take place during the months of August and September, in the year 1912. It is further

1598 Ordered, that either party to this action may examine not only the witnesses herein named, but any other witnesses that either party may desire to examine in Great Britain; provided, however, that the names of said witnesses and their places of residence shall be given to counsel for the opposing party in England not less than two days prior to the examination of each of such witnesses,

and provided further that the examination of witnesses in behalf of defendant shall be first completed and closed and defendant's testimony closed, and that thereafter complainants may examine either of the said witnesses or other witnesses in rebuttal of defendant's testimony taken in the United States or under the commission. It is further

Ordered, that counsel for each of the parties hereto shall give notice to opposing counsel, before the taking of depositions under this order shall be commenced, of his address in London, and delivery of notices herein provided for at such address shall constitute sufficient service thereof. It is further

Ordered, that, all directions herein contained as to time, place, order and manner of examination of said witnesses, may be changed or modified by written consent of counsel for the respective parties, and that by written consent of counsel the examination of said witnesses may be conducted by and before a Notary Public or other official authorized to administer oaths other than the Commissioner herein particularly designated. It is further

1599 Ordered, that the examination of all witnesses under this commission shall be oral, or taken by question and answer in the usual manner of taking oral depositions by examination, cross-examination, and re-direct examination; that the testimony given under such examination shall be reduced to writing, signed by the witnesses and certified by the Commissioner, and by him transmitted by mail to the clerk of this court at the City of Helena, Montana, unless otherwise mutually agreed upon by said counsel for both parties. It is further

Ordered, that all testimony taken under the commission provided for herein shall be taken subject to all legal objections at the trial of this action.

GEORGE M. BOURQUIN,
Judge of the District Court
for the District of Montana.

1600 United States District Court, District of Montana.

In Equity.

No. 1076.

MINERALS SEPARATION, LIMITED, and MINERALS SEPARATION AMERICAN SYNDICATE, LIMITED, Complainants,

vs.

JAMES M. HYDE, Defendant.

Stipulation.

It appearing that the defendant wishes to examine on open commission, at London, England, the witnesses whose names are stated

in the preceding proposed order, and such other witnesses as defendant shall desire to examine, with the expectation of proving, particularly the following facts:

1. That the patent in suit does not disclose anything that was not well known to the public long prior to the date of said patent.

2. That the patent in suit does not set forth an operative process, or one that has ever been of commercial utility.

3. That such commercial operations as have been conducted by the complainants have not been in accordance with the process set forth in the patent in suit.

4. That the patent in suit is deceptive and void under the provisions of R. S., Section 4920.

5. That the defendant was not, while in the employ of Minerals Separation, Limited, one of the complainants, instructed by
1601 the joint patentees or by other engineers and experts in the employ of said Minerals Separation, Limited, in technical details and particulars as to the patent in suit and the installation and use of the process of ore concentration set forth therein.

6. That the three joint patentees are not the original and joint inventors of anything set forth and claimed in the patent in suit.

And it also appearing that the complainants desire to examine witnesses in London in rebuttal of defendant's testimony as heretofore taken in the United States, or as it may be brought out under this commission in the testimony taken in London;

And it also appearing that the witnesses named, and others who may be able to testify relative to the alleged facts as above and in rebuttal, cannot be examined in the United States, and that the facts which defendant expects to prove in support of his defense, and that the facts which complainants expect to prove in rebuttal thereof, cannot be adequately or completely proved by witnesses within the United States;

It is hereby stipulated, consented and agreed by and between counsel for the respective parties that the preceding order may be entered and filed and a commission be issued pursuant thereto.

McCONNELL & McCONNELL,
Solicitors for Complainants.

KREMER, SANDERS & KREMER,
Solicitors for Defendant.

1602 *Deposition of Henry L. Sulman.*

United States District Court, District of Montana.

In Equity.

No. 1076.

MINERALS SEPARATION, LIMITED, and MINERALS SEPARATION AMERICAN SYNDICATE, LIMITED, Complainants,

vs.

JAMES M. HYDE, Defendant.

Depositions of witnesses in behalf of defendant in the above-entitled suit, taken pursuant to a commission issued out of the above-entitled court July 6, 1912, before Joseph Phillips Crawley, of 9 Bishopsgate, London, England, a Notary Public and the Commissioner named in said commission, at the office of Boult, Wade & Tennant, 112 Hatton Garden, Holborn Circus, London, E. C., commencing this 6th day of August, 1912, at 12 o'clock noon.

Present: Walter A. Scott, Esq., counsel for defendant; Henry D. Williams, Esq., counsel for complainants.

HENRY LIVINGSTONE SULMAN, a witness produced on behalf of defendant, having been duly cautioned and sworn, testified as follows:

Direct examination.

By Mr. Scott:

Q. 1. What is your name, age, residence and occupation?

A. Henry Livingstone Sulman; age 51; residence 31, The
1603 Avenue, Brondesbury Park, London, N. W.; I am by profession a consulting metallurgist and assayer, and my place of business is Sulman & Picard, 44, London Wall, London, E. C.

Q. 2. Are you the Henry Livingstone Sulman named as one of the grantees of the United States letters patent No. 835,120, involved in this suit?

A. I am.

Q. 3. Will you please state when you first learned of the use of oil or fatty matter as a means of separating part of the constituents of an ore by flotation?

A. I first learned of the use of oil to separate particles of mineral of an ore by flotation due to the buoyancy of oil in about June, 1894.

Q. 4. Will you state when you first learned of the use of oil or fatty matter in connection with the supplemental action of a gas as a means of floating parts of the constituents of an ore, the ore being suspended in water as a pulp?

A. I first learned of the concomitant use of a gas with an oily substance and as an esential concomitant to flotation about July, 1903. In this answer I do not refer to the more or less acidental presence of some air bubbles in the Elmore oil buoyancy process; but prior to this I had noticed the tendency of oiled mineral to float at a water surface or when brought into contact with bubbles of air during the prosecution of researches into the Cattermole process.

Q. 5. Will you describe somewhat in detail the process in which gas and oily substances were concomitantly used as referred to in your last answer?

1604 A. In carrying out the Cattermole process wherein the metallic constituents are formed into granules in an aqueous pulp by means of oil, these granules being of sensible size can be separated from the gangue material of lower specific gravity in a water upcast. It was noticed under certain conditions that if air bubbles were introduced by accident into such upcast they would tend to float up some of the granules and also some of the insufficiently oiled mineral to the top of the upcast where they were lost by being carried away with the gangue. This was always regarded by us during the first stage of the Cattermole process development as a disadvantage to that process and means were taken subsequently to again sink any metallic portions so floated.

Q. 6. I understand from your answer to question 4 that about July, 1903, you had learned of the intentional use of a gas with an oily substance to produce flotation. If I am correct in this will you describe the process so referred to?

A. A pulp of the ore containing the mineral which it was desired to separate was mixed with a small quantity of oil insufficient to float the mineral by the buoyancy of the oil alone and mixed sufficiently to ensure the attachment of small quantities of oil to the mineral. A gas was then liberated in or generated in the pulp so prepared and it was found that such gas had a tendency to attach itself to the oiled particles. If air were used this was liberated by blowing a stream of bubbles through the mixture in several ways, and if a gas other than air were employed this was generated in the liquid by chemical reactions or by electrolysis.

1605 Q. 7. Where did you see this process operated?

A. This process was devised in the laboratory of my firm at 44 London Wall. It was only experimentally tried on a small scale there.

Q. 8. By whom was this process originated?

A. By Mr. Picard and myself and at a later date Mr. Cattermole co-operated with us in a further development.

Q. 9. Was this the first process of which you learned in which the joint action of oily matter and a gas were utilized for the purpose of floating part of the constituents of an ore?

A. That is my memory of the first time that I learned of the essential use of a gas towards flotation of oiled mineral, although I subsequently found this knowledge had been antedated by Mr. Froment.

Q. 10. And about when, if you remember, did you learn that Mr. Froment had practiced such a process?

A. I learned of the Froment process from the abstract of a patent which was published in the Journal of the Society of Chemical Industry which I saw in August, 1903.

Q. 11. Did you ever yourself operate or see others operate Mr. Froment's process to which you have referred?

A. I have only seen the Froment process operated and have only operated it myself on a small scale in the laboratory or works laboratory. My experiments on the Froment process were confined to test tubes, bottles or somewhat larger vessels. A somewhat larger apparatus was obtained from Mr. Froment at a later date,
1606 but I never saw this effectively worked. Efforts were made to work this apparatus but with no successful result.

Q. 12. Will you state what the somewhat larger vessels were?

A. They were glass vessels, cylinders and such shaped vessels as were at that time used by us in the Cattermole process and might have had a capacity of 1 to 2 litres.

Q. 13. Will you describe somewhat in detail the procedure followed in operating the Froment process with bottles, test tubes and the larger vessels to which you have referred?

A. We made our experiments by following the instructions given in Froment's British specification. We added the ore to a liquid, water, to form a pulp (freely flowing pulp), and also added to this a substance capable of being decomposed by a dilute acid for the purpose of generating a gas; such, for example, as calcite, whiting, or carbonate of soda. A quantity of oily matter sufficient to form a thin layer was then added upon the surface of the pulp and the whole was then well mixed. A small quantity of acid was then added to the mixture with suitable gentle stirring to bring the acid and the gas-producing substance into contact and thereupon the oiled mineral was floated to the surface by the bubbles of the generated gas.

Q. 14. Did you follow Froment's instructions contained in his British specification 12,778 of 1902 in the matter of agitating the mixture of the ingredients you have named?

1607 A. I did agitate gently for the purpose I have stated, that is, to bring the acid into contact with the decomposable substance. A greater degree of agitation was found harmful in producing the flotation as the type of float material produced was such as very readily broke up, in my experience, and anything like vigorous agitation defeated the object of the invention.

Q. 15. Was this Cattermole process to which you have referred in which it was desired to form the metallic constituents into granules ever operated commercially, that is, I mean for the purpose of profits in concentrating ores?

A. Not by myself, but I believe it was worked profitably for a period in Australia.

By Mr. Scott: The reference to the use of the Cattermole process in Australia is objected to as hearsay.

Q. 16. I understand from your answer that you have no personal knowledge that the Cattermole process was ever operated commercially?

A. I have not myself operated the Cattermole process for profit but was instrumental with others in designing and erecting a small scale plant which would treat considerable quantities of ore and this model plant was sent out to Australia. Beyond this I cannot go as to the commercial working of the Cattermole process.

Q. 17. Referring to your description of your procedure in operating the Froment process, you have stated that you gently stirred the mixture to bring the acid and the gas-producing substance
1608 into contact. Is stirring or agitation necessary in that process for any other purpose than to bring the acid into contact with the gas-producing substance?

A. Agitation in my experience of the Froment process should be given in two stages. Sufficient agitation firstly to get the oil into efficient contact with the mineral to be subsequently floated. This first agitation is not responsible for the production of the float material required. The second agitation is for the purpose of effecting the due contact and uniform contact of acid with the decomposable substance and much less agitation is required and in my experience is necessary for the second purpose, having regard to the nature of the float material produced.

Q. 18. In all oil flotation processes sufficient agitation is necessary, is it not, to distribute the oil in such a manner that it will come into contact with the particles for which it has an affinity?

A. The first requisite of any oil concentration process is to obtain efficient contact between the oil and the mineral and suitable methods must be employed to effect this. Where the oil is in large relative quantity to the mineral violent agitation is unnecessary and may be very harmful. With decreasing proportions of oil more vigorous agitation or mixing is necessary to ensure such efficient contact of oil with the mineral particles. The agitation may therefore be said to be roughly proportioned to the work to be done in bringing about contact between large or small quantities of oil in regard to the mineral.

1609 Q. 19. At the time you first learned of the Froment process in August, 1903, were you connected with Minerals Separation, Limited?

A. I do not recall the date without reference to the formation of Minerals Separation, Limited, but I was associated with the various gentlemen who formed Minerals Separation, Limited.

Q. 20. In operating the Froment process what kind of oil did you use?

A. We tried a large variety of oil. Hydrocarbons, heavy and light, certain fatty oils also.

Q. 21. Will you give the specific names of these oils which you tried?

A. Heavy and light lubricating oils, cylinder oils, lighting oils and even light volatile hydrocarbons. At this length of time I cannot recall all that were used, but I think of turpentine, oleines,

There were doubtless others, but I do not recall them specifically. Every effort was made to locate the factors which would make the Froment process successful and I know that a variety of oils were therefore experimented with to this end.

Q. 22. What kind of an apparatus did you use when you first operated, or saw operated by others, the process set forth in the patent in suit?

A. The apparatus that I first saw the agitation froth produced in as described in the specification referred to was the ordinary gabbet apparatus consisting of a vessel with rotating cone and with suitable baffles. The cone was rotated at a high rate of speed, about
1510 1000 revolutions per minute, and the size of the vessel was such as would contain about 2 litres of liquid.

Q. 23. How was the concentrate removed from the remainder of the material when this apparatus was used?

A. When I first saw this thick froth produced it was so coherent and resistant that we were able to remove the greater portion by spooning it or ladling it from the surface of the liquid. But this was necessarily an imperfect method and a funnel with a long stem was then introduced into the liquid below the froth and water poured in through the funnel until the froth was floated over the rim of the containing vessel and the overflow caught in a basin placed beneath it.

Q. 24. Where did this operation take place?

A. This took place in the experimental laboratory of Minerals Separation, Limited, at Aldermanbury Avenue, London, E. C.

Q. 25. Did you operate the process in any other manner at the laboratory referred to by you in your last answer?

A. Subsequently we fitted a spitzkast or spitzlutte apparatus to the battery of agitation vessels, and at the end of the series of these, upon which spitzkast or spitzlutte the agitation froth was floated off and the gangue allowed to sink.

Q. 26. How was the material conducted from one vessel to another in the battery of agitation vessels, and how was it conducted from the battery to the spitzkast?

1611 A. My memory of the battery is that these were connected with one another by fairly broad pipes having regard to the size of each vessel and the end pipe was bent upwards and then downwards and discharged the contents of the last vessel onto a small tray or open launder which communicated with the first spitzkast or spitzlutte.

Q. 27. Was the connection between the last agitating vessel of the battery and the spitzkast substantially similar to that illustrated in Figure 1 of the U. S. patent 835,120, the patent in suit?

A. It was so substantially in design, although this diagram appears to somewhat emphasize the height and the length of the pipe H. For the purposes of the illustration the spitzkast shown is placed in the reversed direction to the flow of the current through the battery. My memory of this apparatus is that the spitzkast was placed in the same line of flow and that there was a comparatively short length of pipe H.

Q. 28. During the operation of this apparatus was an up-current of water maintained in the several spitzkasten?

A. At first this was so for the purpose of separating the gangue into heavier and lighter sands and slimes, for which purpose a small up-current was introduced into the spitzlutte at the bottom in order to suitably classify the gangue products as described. Subsequently the spitzlutte were replaced by spitzkasten where no up-current was used.

Q. 29. Do you remember whether this apparatus was built
1612 and operated before you applied for United States patent No. 835,120 in suit?

A. That I cannot positively say, but I should think it very probable. This answer only refers to the pointed box portion of the patent in suit, as the battery of agitation vessels was already installed and had been working in connection with the Cattermole process.

Q. 30. Have you any knowledge as to whether an apparatus such as you have just described was ever put to practical use, as distinguished from use for a laboratory demonstration?

A. That I have no positive knowledge of; I can only say that I think it is most likely that such apparatus was used first of all in Australia, as a very efficient froth formation and separation was obtained by us in precisely this type of apparatus in Aldermanbury and the first apparatus for giving effect to this in Australia were, I believe, based upon it.

Q. 31. You have no personal or positive knowledge, then, I assume, as to whether apparatus of the type you have described was ever used in Australia or elsewhere for practical purposes as distinguished from a laboratory experiment. Am I correct in this?

A. You are correct, as my work and those who were associated with me in this matter was mainly confined to investigation and experiment in London.

Q. 32. When you for the first time saw a process operated according to the United States patent 835,120 in suit, who was present and who actually conducted the operation?

1613 A. Mr. Ballot was present and was supervising the experiment which was being performed by Mr. A. H. Higgins, who was working under our joint direction.

Q. 33. What led to your presence and that of Mr. Ballot upon this occasion?

A. At some date a week or two prior to our discovery of the air agitation froth, Mr. Ballot, Mr. Picard and myself had been in close consultation as to a number of factors which we considered required finally investigating and quantifying. They concerned mainly the operation of the Cattermole process, but also had in view the clearing up of a number of loose-end observations noticed in previous developments of oil concentration work. Mr. Ballot, Mr. Picard and myself found it necessary to draw up a schedule of such factors as we considered required investigation, and we instructed the experimental staff at Aldermanbury to carry these out; the carrying out of these final investigations was done under the immediate supervision of one or other of us throughout the whole of them. The factors to be in-

vestigated were as follows: In a report dated March 3, 1905, made by Sulman & Picard and addressed to John Ballot is recorded the work which the whole three of us were doing then and this report is not so much for the information of Mr. John Ballot as the putting on record of work which he and we had jointly done, for purposes of reference afterwards. In it we say on page 2:

"We are in full agreement with the rest of Mr. Higgins' observations and may summarize the work now being done at Alder-
1614 manbury Avenue as the determination of the following factors:

"1. Influence of acidity on granulation.

"2. Influence of temperature on ditto.

"3. Influence of speed of gabbet agitation on granulation.

"4. Influence of ratio of ore to liquor on granulation.

"5. Influence of metallic salts on granulation.

"6. Influence of the size of particles and of the influence of slimes on granulation.

"7. Influence of the amount of oil on granulation.

"The above factors are being determined on

(*a*) Oleic acid.

(*b*) Residuum oils.

"Mr. Higgins' present report is therefore the first instalment of the above scheme of trials."

Mr. Higgins was sending in in like fashion to Mr. Ballot the daily records of these trials proceeding under the joint supervision of the three of us. It was in the carrying out of the latter factor, namely, the amount of oil in its effect upon granulation that in reducing the amount used beyond all previous quantities in regard to the mineral, that we found granulation to decrease or even cease when a certain limit was reached and that coincidentally a mineral froth began to take its place. When we decreased the amount of oil to about .6 per cent. upon the ore, granulation had ceased to appear and a very considerable proportion of mineral was found to float to the
1615 surface as a thick froth. We still further decreased the amount of oil until we found that with .2 to .1 per cent. of oil on the ore practically the whole of the mineral came to the surface as a thick blackish matted froth.

At the request of counsel for the complainants the Commissioner marks for identification the document referred to by the witness in his last answer as "Sulman and Picard Report, March 3, 1905."

Q. 34. Can you remember at this date the substance of Mr. Higgins' report which you refer to in the document identified as "Sulman and Picard Report March 3, 1905," or if you can, will you produce that report?

A. This report has been handed to me by counsel and before referring to it I will state that at this date the discovery of the agitation froth had not been made. Mr. Higgins' report therefore deals with some of the prior factors of granulation set out by us in our schedule of items to be investigated. Mr. Higgins' report is dated March 2,

1905, and is headed "Report on the Conditions of Granulation." It deals in detail with the results of (1) the influence of acidity in granulation, (2) upon the influence of heat on granulation, setting forth in detail the experiments which he tried under the directions he received (3) with the influence of the thickness of the pulp and (4) with the influence of peripheral velocity of cone. On the last page of his report he notes that experiments are also to be
1616 carried out on the influence of the quantity of oil present in order to complete the information regarding granulation.

At the request of counsel for the complainants the Commissioner marks for identification the document referred to by witness in his last answer as "Higgins' Report March 2, 1905."

Q. 35. Do you remember whether Mr. Higgins made any report setting forth the result of his investigation of the seventh topic named by you, namely, the influence of the amount of oil on granulation?

A. Mr. Higgins submitted a record of the experiments he carried out in the investigation which was set him by us in regard to the influence of the amount of oil on granulation. This report or record of Mr. Higgins' followed the usual course of such reports and was sent in a day or two after the facts had been noticed by us. This report is now handed to me by counsel and bears date March 16, 1905. It is headed "Further Report on the Conditions of Granulation" and under the next heading "Influence of the Percentage of Oil" Mr. Higgins describes the formation of the float froth.

At the request of counsel for the complainants the Commissioner marks for identification the document referred to by the witness in his last answer as "Higgins' Report March 16, 1905."

Q. 36. As I understand you, to put the matter briefly, Mr.
1617 Higgins was instructed to ascertain the effect upon granulation of varying the various factors of the Cattermole process and that while carrying out these instructions he found that with the quantity of oil too small to properly granulate the concentrates, flotation resulted. Is this the correct understanding?

A. Mr. Higgins was a capable experimenter fully qualified to carry out intelligently all instructions given to him. The instructions given in regard to each of the factors was that they were to be investigated to their full limit in order to quantify and also to explore the limits of application of the Cattermole process. These experiments were carried out by him in the constant presence, although not the continuous presence, of all of the patentees, Mr. Ballot, Mr. Picard and myself, and he recorded the result of such experiments.

Q. 37. Do you mean that while Mr. Higgins was conducting his laboratory work either you, Mr. Picard or Mr. Ballot or more than one of you together were present watching him?

A. I do mean that, although we were not present the whole of the time. Mr. Ballot had his office business to attend to and Picard and myself were also carrying out other investigations on the oil process at our laboratory. Aldermanbury Avenue is situated about

5 minutes' walk from both these offices and one or other of us were constantly making journeys backwards and forward to Aldermanbury Avenue to see for ourselves the progress which the investigations were making and which Mr. Higgins was fully competent to
1618 carry out on instructions received even when we were not present.

Q. 38. I take it from your last answer that while you, Mr. Picard and Mr. Ballot made occasional visits to the laboratory where Mr. Higgins was working that Mr. Higgins was alone more or less of the time while conducting his work?

A. He may, and probably was, alone for some periods, so far as Mr. Ballot, Mr. Picard and I were concerned, but others of the experimental staff of Minerals Separation were also present at Aldermanbury Avenue, carrying on other researches which had been set them by ourselves at the same time. Minerals Separation had several capable assistant experimenters, all of whom, or nearly all of whom, had been trained by us in oil concentration work and experiment, and whom we could rely upon to diligently carry out our instructions without supervising them every minute of the time.

Q. 39. Did some of these other members of the staff help Mr. Higgins in the investigation of the seven subjects referred to by you in Sulman and Picard's report of March 3, 1905?

A. My memory is that the other experimenters were engaged on the work other than the seven points mentioned which had been set for Mr. Higgins to investigate, by us.

Q. 40. Were either yourself, Mr. Picard or Mr. Ballot present at the time Mr. Higgins first experimented in pursuance of the instructions set forth at the bottom of page 2 of the Report of
1619 March 3, 1905, with an amount of oil falling within the limits designated in United States patent 835,120 in suit?

A. Mr. Picard and I were not present at the first discovery that by dropping the oil quantity below the last granulation limit the agitation froth was produced, but I have reason to believe that Mr. Ballot was present, as he came round to my office, and at once called me to go with him to see what had been the result of such oil diminution, and I went with him at once. The experiment was again carried out in my presence. I understood that it had been found to occur only a comparatively short time before I was called to see the result of the carrying out of this No. 7 instruction to its further limit.

Q. 41. I take it that this was not the first information you had ever had to the effect that froth flotation could be secured by the use of a very minute quantity of oil; am I right in this?

A. In regard to the formation of a froth of this nature, which is so specific in its character and in the presence of an amount of oil so relatively exceedingly minute as in this instance, this was the first time that I had had experience of any such phenomenon. You have used the word "froth" as if this were a term widely applicable to float material produced at a liquor surface, but it has a very wide and loose use, and is frequently very misleading. If by "froth" is meant an assemblage of bubbles at a liquor surface, such bubbles being separated from each other by a contaminated liquor film, the

majority of such froths would be useless for any purpose of
1620 separating mineral from gangue. Thus, we may have a soap froth which will carry but little mineral or gangue, and will differentiate between neither, we may have a saponine froth which will hold neither mineral nor gangue, and many other froths of the same nature. I have heard the float material produced by the Froment reaction described as a froth, but it is a tender and evanescent assemblage of bubbles of carbon dioxide carrying mineral, and is not comparable in nature or character with the agitation froth described in the patent in suit. For a froth to be effective at ordinary ranges of temperature between, say, air temperature and well below boiling, the froth must be coherent and permanent for a considerable time. Such froths are typified in my experience only by the agitation froths produced by vigorously agitating an ore pulp with very minute amount of oil, that is to say, less than one per cent. on the ore in the presence of air. Therefore, in answer to your question, this was the first occasion upon which I had seen a heavy, thick, matted froth, which was permanent and coherent, produced.

Q. 42. Can you form any idea at this date as to how long a period of time elapsed after Mr. Ballot called your attention to Mr. Higgins' operations under the seventh instruction referred to in the Report of March 3rd, 1905, and the construction and operation of the apparatus which you have described as being substantially similar to that illustrated in Figure 1 of the drawing of the United States patent 835,120 in suit?

1621 A. My memory is that the development of the agitation froth process, and in regard to apparatus to give effect thereto, was proceeded with, with dispatch and interest. If my memory serves, Mr. Higgins for a short time thereafter was engaged in finishing the investigation of one or two factors still outstanding, and my memory further is that others of Minerals Separation staff, among them Mr. Leechman, were occupied in getting together the agitation froth apparatus and experimental plant. This must have occurred in the week or two immediately following the discovery of what happened when oil was employed in quantities quite insufficient to granulate the minerals in the pulp.

Q. 43. Referring to your answer to question 17, do you find anything in the Froment patent regarding agitation in two stages; I refer particularly to the example of his process described in lines 33 to 42 of the complete specification?

A. I do not find the two stages of agitation mentioned in the example of Froment put to me, but I was interpreting the specification intelligently and according to the knowledge of any one who had had previous experience in oil concentration work. I think it will be evident that the example quoted would be best carried out if precautions had been taken to bring the mineral into efficient contact with the oil before liberating a gas within the mixture.

Adjourned to Wednesday, August 7th, 1912, at 10:30 A. M., at the same place.

1622 London, August 7th, 1912.

Met pursuant to adjournment. Present, counsel as before.

Direct examination of Henry Livingstone Sulman continued:

Q. 44. In the operations which you referred to in your answers to Questions 6 to 8, these operations having been originated by yourself and Mr. Picard, what kind of an apparatus did you use?

A. The apparatus we used was of laboratory type in all cases, that is to say, the vessels of various shapes were of glass, and the tubes and connections were of glass or India rubber; cylinders, beakers, bottles, basins, plaques and so on. In one or two instances small adjuncts were made of tin or tinned iron.

Q. 45. Will you describe, as nearly as you can now remember, the part of the apparatus used for mixing the oil and mineral?

A. So far as my memory serves me, several types of mixing were employed. In some cases the mineral was pre-oiled in agitation apparatus of the cone-gabbet type, in other cases by vigorous hand stirring or by shaking in bottles. In other cases the mineral was not pre-oiled, but the oil was blown in by air, sometimes aided by steam, either as sprays in the case of non-volatile oils, or as vapor, in the case of the more volatile hydrocarbons. I remember that scent-spray bottles were used, and several arrangements of induction pipes for atomizing purposes.

1623 Q. 46. What degree of success did you meet with in operating this process with the apparatus you describe?

A. Our success in these operations was of very imperfect nature, and our specification rather represented a pious hope that we should ultimately attain success on these lines. The floats obtained were in general thin and tender, and were mainly of the nature of surface-tension effects at a water surface. We tried a great many experiments on various lines indicated, but in no case were we able to attain to a persistent and coherent froth. After a considerable amount of time and experiments we discontinued our efforts in this direction, owing to the small degree of success experienced and from the apparent improbability of such processes developing into a commercial method for mineral separation from gangue.

Q. 47. About what quantity of oil relative to ore did you use in these operations?

A. So far as I remember, the quantities used of oily matter were always substantial, that is to say, they would always be in excess of one per cent. upon the ore taken. At that time we had no knowledge of the effective use of quantities of oil below the proportions employed by Cattermole, and regarded these Cattermole quantities as being likely to be required in flotation work of the nature we were experimenting upon.

Q. 48. Is the apparatus which you have described as being used in these experiments of substantially the nature shown in Figures 1 and 2 of the drawings of Sulman and Picard's U. S. patent

1624 793,808, and are you the H. L. Sulman to whom that patent was granted?

A. I am the Henry L. Sulman, one of the grantees of this patent, and the apparatus shown in all three figures reproduces, diagrammatically, essential features in apparatus experimentally employed by us, although in none of the three cases are the diagrams shown exactly those of apparatus employed by us. The diagrams were prepared by us in consultation with our patent agent, and gave rather more precise expression to the type of experimental apparatus we had used in our laboratory. I may mention that our patent agent, Mr. Ballantyne, attended at our laboratory and saw many of these experiments in order to aid us in the drawing of the diagrams referred to in this specification.

Q. 49. You have described an apparatus substantially like that shown in Figure 1 of the patent in suit, No. 835,120, as having been constructed and operated. Will you state whether you built any other apparatus, at a later date, for the purpose of operating the process of patent 835,120?

A. The apparatus shown in the diagram of the patent in suit closely represents that which we jointly designed, and which was built at Aldermanbury avenue for the agitation-froth process. I gave expression to this point design in a drawing of about May 3rd, 1905 (witness produces Report dated May 3rd, 1905, and drawing).

This drawing confirms the description I gave of the plant
1625 in my answer to question 27. This apparatus was built, under our supervision, by Minerals Separation staff, at Aldermanbury avenue, and was subsequently modified in some details. I made the drawing produced myself. I, personally, built no other apparatus, but was cognizant of the modifications of the plant referred to. So far as my memory serves me, these modifications resulted in eliminating the aeration table for the treatment of the coarse sands, and I think it was not very long thereafter before the up-currents to the pointed boxes were dispensed with.

Q. 50. Did you see any other apparatus for operating the process of the patent in suit at the laboratory at Aldermanbury avenue?

A. My memory on this point is insufficient, so far as Aldermanbury avenue is concerned. Messrs. Minerals Separation afterwards took other works at Cowper street, and later at Charlotte street, London, E. C., in which further types of apparatus were built and operated.

At the request of counsel for complainants, the Commissioner marks for identification the Report and drawing produced by the witness in his answer to Q. 49 as "Sulman and Picard Report, May 3, 1905," and "Sulman Drawing Accompanying Report May 3, 1905."

Q. 51. What was the next apparatus for the purpose of practicing this process which you saw, and under whose direction was it constructed?

1626 A. Apart from Figure 2 of the drawing in the patent in suit, as to which I have not answered, my memory of the next type of plant is that it had a series of square wooden boxes for the agitation vessels, in place of the cylindrical glass vessels with baffles, which we had used hitherto. This plant was constructed by Minerals Separation staff, under our supervision, at one of the works subsequently taken after the Aldermanbury avenue experiments.

Q. 52. Do you remember where the laboratory was located in which the square box machine was built?

A. I have no definite memory of the locality. I recall that Minerals Separation for a while had a third works for experimental operations at Phipp street, London, but I cannot say at which of these works the square boxes were first erected.

Q. 53. Will you please name in chronological order the different laboratories in which work was carried on for the purpose of demonstrating the process of the patent in suit?

A. Subject to correction, I think the order was our own laboratory in London Wall, where from 1902 until March, 1904, all the experimental work in connection with oil concentration processes was carried out; even subsequent to this date a considerable volume of research work was always proceeding on these matters at our laboratory. The first experimental works taken by Minerals Separation was at Aldermanbury avenue, and thereafter, subject to correction, I think the order of the other works was Phipp street, Cowper street,
1627 Charlotte street, and, finally King Johns Court, Great Eastern street, all in London, E. C.

Q. 54. In the use of the apparatus, represented substantially in the patent in suit, and shown in the sketch identified as "Sulman Drawing Accompanying Report May 3, 1905," which apparatus, I understand, was operated in the Aldermanbury avenue laboratory, what was the purpose of classifying the gangue material by means of the three spitzkast or spitzlutte shown?

A. The object of the classification of the gangue in the compound spitzlutte, shown in the drawing referred to, is set forth in our Report of May 3rd, 1905, wherein it is indicated, that by this means any coarse oiled mineral particles, not caught up and floated off with the froth, may be induced to sink in the first compartment of the spitzlutte, and freed from fine sands or slimes, with the idea that such oiled mineral might be recovered from the sunken product by passing over the aeration table. At the date of our Report, May 3rd, 1905, we had not fully grasped how dense and coherent the agitation froths were, and having regard to the previous flotation experiences we anticipated that a considerable quantity of the coarser mineral particles would not be held in the froth, and that special steps would be required to deal with this. We shortly found thereafter that such precautions were practically unnecessary, and, as I have stated, they were subsequently discarded. Naturally, the proportions and size of
1628 the heavy mineral particles would be dependent on the mesh of crushing adopted for the particular ore submitted to such a method of separation as described in the patent in suit, and such a

mesh was adopted in subsequent operations as would permit practically all the mineral particles being retained by the froth.

Q. 55. Can you remember, at this date, about how long you continued the use (by "you" I intend to include Minerals Separation or the parties in interest) of the apparatus shown in the drawing accompanying Report of May 3, 1905?

A. My memory does not serve me accurately, although my impression is that the period was a comparatively short one. The various members of Messrs. Minerals Separation staff were actively engaged, under supervision, in developing the mechanical details of the apparatus, indicated in the drawing, and progress, in taking advantage of the specific characters of the froth, was rapid..

Q. 56. Was more than one apparatus constructed following substantially the drawing accompanying Report of May 3, 1905?

A. Several sets of apparatus for continuous work, all closely following the essential principles of the drawing, were constructed, and small test apparatus was also designed by us for the experimental investigation of parcels of ore too small to be employed in the continuous apparatus, and for experimental work in connection with new ores.

Q. 57. As I understand the matter, the first apparatus fol-
1629 lowing the design shown in Sulman drawing accompanying Report of May 3, 1905, was a small laboratory apparatus. After the construction of this first apparatus, was a comparatively large-size machine, built on the same general design, and if so, about what were the dimensions and capacity of such larger machine?

A. It is difficult to draw a hard and fast line between what is laboratory apparatus and one of commercial or practical utility. The drawing in the patent in suit and the drawing by myself, before referred to, show glass agitation vessels combined with a spitzlutte apparatus which was 2 feet, 6 inches in length. This apparatus was capable of treating a very considerable quantity of ore, and if operated continuously would probably have been able to efficiently deal with perhaps half a ton of ore in twenty-four hours; possibly more. The next apparatus was built of considerably larger capacity, in which plant the glass vessels were replaced by wooden ones, and the capacity for ore treatment again greatly increased. I cannot from memory give the dimensions of this next type of apparatus. Several plants of this nature were built, from time to time, of varying and increasing capacity, details of which, after this lapse of time, I cannot carry in my own memory. There were square boxes for agitation purposes, retaining at first the cone mixer, but afterwards the cone agitator of the gabbet type was replaced by cross-shaped agitators with four arms at right angles.

1630 Q. 58. Can you remember how many of these machines were built following generally the plan of the drawing accompanying Report May 3, 1905?

A. There were several, but I cannot say how many; as after a while subsequent to Aldermanbury avenue works the working of the larger scale plants and their erection passed more specially into the hands of the Minerals Separation staff at these various works, and my

own work in connection therewith became of a more consultative nature. Work was also done in Australia, of which I have no personal knowledge.

Q. 59. After Minerals Separation, Limited, moved from Cowper street to Charlotte street, was one of these machines constructed by you or under your supervision?

A. I do not rememebr that a plant of this nature was constructed under my supervision at Charlotte street.

Q. 60. Did you see such an apparatus constructed at Charlotte street?

A. I did.

Q. 61. Did you see that machine after it was completed, and did you see it operated?

A. I did.

Q. 62. Did you yourself participate in the operation of that machine?

A. No, my memory is that I only saw it whilst it was being worked by the Minerals Separation staff.

Q. 63. Can you give us some idea of the size and capacity of this machine which was constructed at Charlotte street?

1631 A. No, I am afraid my memory is not sufficiently accurate to give you any details of its size or capacity.

Q. 64. Did this machine constructed at Charlotte street have glass agitating vessels, or of what material were they made?

A. They were made of wood, so far as my memory serves me.

Q. 65. They were larger than the glass agitation vessels first made, were they not?

A. Certainly.

Q. 66. Did the battery of agitating vessels discharge the pulp into a launder or upon an apron, such as designated by the letter O in Figure 1 of the drawing of the patent in suit?

A. My memory is not particularly accurate to give you a definite answer.

Q. 67. Did the machine constructed at Charlotte street have a series of spitzkast or spitzlutte?

A. I believe that there were no compound spitzkast at Charlotte street, that is to say, of the series type for the grading of the gangue into different sizes.

Q. 68. Can you state approximately the capacity of the agitating tanks forming part of the machine built at Charlotte street; by approximately I mean whether the capacity was one gallon, say, or twenty gallons, or a hundred gallons?

A. My memory of the mechanical details and the capacities and dimensions of the Charlotte street plant is now somewhat vague, but the capacity would be certainly greater than one gallon for each agitation box, and considerably less than one hundred gallons.

1632 Q. 69. Was the diameter of these agitating tanks, that is, of each of them, about three or four feet or more?

A. Certainly under three or four feet; much under.

Q. 70. And about what was their height?

A. I do not accurately remember the number or the respective sizes of the agitating vessels which were provided at Charlotte street. My impression is that the size progressively increased, to a certain extent, and the largest may have had agitation boxes two feet or perhaps more in depth.

Q. 71. Did you have anything whatever to do with the designing of this machine which was built at Charlotte street?

A. I was no doubt consulted as to its design, but I do not remember any very specific points in connection therewith.

Q. 72. How did the results secured by the operation of the Charlette street machine compare with those secured by the use of the apparatus having glass agitating vessels which I understand was the first machine built to operate continuously?

A. Speaking generally, the same high recoveries of mineral were obtained in the large, as in the small, apparatus.

Q. 73. Is the machine which was built at Charlotte street the last one that was built, following the design shown in Sulman drawing accompanying Report of May 3, 1905?

1633 A. I do not know that I have stated that the apparatus built at Charlotte street followed with exactness the drawing of the patent in suit or the drawing which I made under date of May, 1905, but it followed this drawing and design in all essentials. Thus, it had a battery of communicating agitating vessels, through which the pulp was passed continuously with high agitation of the pulp in each, the passage of the pulp through these agitation vessels being serial. The agitation vessels were connected with spitzkasten, in which the agitation froth generated, was floated off, whilst gangue was permitted to sink therein. I have stated that in the Charlotte street plant the glass vessels were replaced by square wooden boxes, and that the type of agitator was also changed. As I have stated before in connection with the mechanical expression which was given to the drawing in the patent in suit, at Charlotte street and the other works, my memory is not accurate.

I should say that in essentials all the plants built by Minerals Separation have followed the design given in the patent in suit, subject to such mechanical modification as the practice of the process would naturally lead to on a large scale.

Q. 74. In the operation of the apparatus shown in Sulman drawing accompanying Report May 3, 1905, and in the operation of the subsequent machines of that type which were built up to the time of and including the apparatus built in the laboratory on Charlotte street, was all of the valuable part of the ore recovered as a

1634 froth, or did more or less of the mineral sometimes float as a film?

A. A froth separation of the valuable mineral was always aimed at and substantially obtained. If film flotation was effected that was an indication that the plant was not being operated to its purpose and best effect, and the plant operations were thereupon adjusted and regulated to give a coherent froth and not a film.

Q. 75. Then, as I understand it, during the operation of these

machines more or less mineral did float as a film at times; am I right?

A. No. I do not think you are correct there. Unless the running of the plant were in any way hindered or interfered with, such as by a temporary failure of the ore supply, or at the beginning and the end of the operation, no film flotation was permitted.

Q. 76. When the film flotation was noticed what operations were adjusted and regulated, and in what manner were they adjusted and regulated to give a coherent froth and not a film?

A. Broadly speaking, films would be formed by pulling out the froth produced, by the surface tension effect of a large free water surface on the spitzkasten; therefore, it was necessary to run the agitation portion of the plant to an extent which would produce a froth capable of occupying the free water surface of the spitzkast. Thus, on starting the plant the first portions of froth would be pulled out into a film for a few minutes, and by this means the sur-
1635 face tension of the water was reduced. Thereafter the froth piled up and covered the surface of the spitzkasten without further surface tension breakdown. The two adjustments therefore necessary to be made to prevent the destruction of the agitation froth potentially produced at the point where the pulps entered into the spitzkast were to keep the supply of ore up to the capacity of the particular plant, and, secondly, to avoid too rapid a liquor overflow from the spitzkasten. Another point which required observance was that the temperature of the circuit should be maintained at the degree found most suitable for the production of coherent froth with any given ore.

Q. 77. Did the flotation of mineral in the form of a film ever occur at any time other than at the beginning of the operation of the apparatus when the froth was first beginning to spread over the water surface, and at the end of the operation, when the froth was leaving the water surface?

A. In my experience at such times, and also by temporary interference with the other conditions which I have mentioned, such as irregularity in supply of ore or oil, or considerable fluctuations in temperature. Given the proper conditions ascertained in regard to each plant and ore operated upon, a production of a coherent froth was continuous whilst such conditions were maintained.

Q. 78. As I understand your explanation of one of the causes of the appearance of the mineral in the form of a film as dis-
1636 tinguished from a froth, this cause consisted in the fact that when the amount of froth was not sufficient to cover the entire surface of the water, in the spitzkast or spitzlutte, the froth did not have sufficient coherency to maintain itself as a froth, but spread out as a film; am I right?

A. That is so. The surface tension of water is a force of very great magnitude, capable of breaking down liquid and plastic materials into films of great thinness. This is a fact known generally, and it would be the obvious precaution to apportion the spitzkasten surface to the requirements of the float material yielded by any given ore.

Q. 79. In what way was the oil added during the operations with the apparatus which we have been discussing?

A. Two methods I recall were used for adding the oil according to the size of the plant operated. In small scale apparatus the quantities of oil were relatively so small that if these were added drop by dry, intermittances of oil supply might well occur, and due regulation of such small quantities was difficult. In such cases a solution of soap, that is to say, oleate of soda, was employed, and this solution, containing the oil in a more dilute condition, was capable of closer regulation and qualification. The soap solution on falling into the acid liquor of the mixer was immediately decomposed into very finely disseminated globules of oil and efficiently oiled the mineral without risk of intermittency of oiling. In the larger scale apparatus the oil was added directly either by drops or in a very
1637 thin stream, as the proportion of mineral present was sufficient to engage all the oil, as, and when added. The oil was added in the first of the series of mixers to the pulp containing the ore.

Q. 80. Following the operation of the apparatus made at Charlotte street, in what kind of an apparatus did you next see tests of the process of patent 835,120 in suit?

A. I have no distinct memory of the details or size of the various plants built and operated at Charlotte street. I was consulting metallurgist to Messrs. Minerals Separation, Limited, and my time was very largely occupied in further research into oil processes on their behalf. My time was not exclusively retained by Minerals Separation, Limited, and I have and had a large private professional practice to attend to. The mechanical details of the various plants were left largely in the hands of Minerals Separation, Limited, and my services were only required now and again upon any special matters which might arise.

Q. 81. Have you any recollection of seeing an apparatus constructed by Minerals Separation after the plans of an apparatus operated by the Sulphide Corporation in Australia?

A. I was not personally cognizant of the work done in Australia, beyond knowing that Minerals Separation were in constant communication with their own staff in Australia, and I believe, with the officials of the Sulphide Corporation. No doubt I was told by
1638 Mr. Ballot of the work which was done in Australia, and I have no doubt that I saw apparatus constructed by Minerals Separation after plans or apparatus operated by the Sulphide Corporation, but I have no recollection of any specific details thereof.

Q. 82. Do you remember of having seen drawings or a description of the plant of the Sulphide Corporation, that is, the Minerals Separation plant in Australia?

A. It is possible that I saw drawings and heard the description of such plant, but I have no memory of this.

Q. 83. Do you remember of receiving any request, at this period of time, to make an endeavor to recover the valuable part of the mineral more fully in the form of a froth, as distinguished from a film?

A. I have no recollection of any such request, my impression being now that at that period the separation was always effectively in the form of a froth, but it is quite possible that the apparatus required adapting to the requirements of an ore in regard to the production of the most coherent froth.

Q. 84. You do remember, then, do you not, the necessity of making some changes in the apparatus at London for the purpose of securing a coherent froth; am I right?

A. About the beginning I think, of 1907, and from that date onwards until the end, I think, of 1910, that is, if I am correct, for a period of about four years, Mr. T. J. Hoover was appointed works manager and engineer for Messrs. Mineral Separation plant,
1639 and continued to act in that capacity. During this period I had very little to do with the mechanical details of the plant, and, in fact, was not so often present at the works. I am, therefore, not well acquainted with the details of mechanical changes in the apparatus used in London throughout this period, and I understand that the question asked would fall within this period.

Q. 85. Prior to the engagement of Mr. T. J. Hoover as engineer, do you remember the necessity of making changes in the apparatus at London for the purpose of securing a coherent froth?

A. My memory of the froths produced is that they were always coherent when produced, and that it was only necessary to prevent their being broken down by means of the factors, which I have already described. I remember that the tray or launder was gradually dispensed with, but when, and over what period it disappeared, I have no distinct recollection.

Q. 86. Did the idea of dispensing with the tray or launder originate with you and Mr. Picard and Mr. Ballot?

A. That I have no distinct recollection of, though it was doubtless discussed between us.

Q. 87. Was the tray or launder dispensed with before or after Mr. T. J. Hoover was appointed works manager and engineer for Messrs. Mineral Separation, Ltd.? In this connection I assume that the tray or launder referred to by you is that designated by the letter O in Figure 1 of the patent 835,120 in suit, and designated by the word launder in Sulman drawing accompanying report May 3, 1905?

1640 A. That I am unable to say. I have no recollection of the period at which it was discarded.

Q. 88. What was the reason the tray or launder was dispensed with?

A. I should think for the purpose of making the plant more compact and for diminishing the free water surface.

Q. 89. What was the purpose in using the launder or apron in the first place?

A. Merely, I think, to convey the sufficiently agitated pulp to the surface of the spitzkasten. There is no apparent reason why the spitzkasten should not have been placed fully against the end of the outlet pipe. Possibly, also at that time, when we were under the

impression that coarse oiled particles might not be caught in the froth, we wished to bring them in contact with air and float them initially by skin flotation or surface tension effect, and thus get them caught up in the froth. As I have pointed out, this was a difficulty which we subsequently found not to occur to any appreciable extent, but no doubt the launder persisted in the general type of the apparatus long after its fancied use had become unnecessary. As usual in plants of such nature, compactness was constantly sought after. We were aware before the date of the patent in suit, that coarse oiled particles could be floated by surface tension at the water surface if they were brought previously into contact with air.

1641 Q. 90. You have referred to the presence of air in the Elmore process. It is a fact, is it not, that in the Elmore process an amount of mineral was floated in excess of that which could have been floated by the buoyancy of the oil alone?

A. I have seen it stated that in the Elmore process an amount of mineral could be floated in excess of that due to the buoyancy of the oil alone, but my experience of that process is that the mineral floated was amply accounted for by oil buoyancy, having regard to the amounts of mineral and the mass of oil in which they were carried. It is, however, a fact that the Elmore separated oil and mineral did usually contain a few small bubbles of air and also small globules of water. These could be seen when a layer of the separated oil was spread out in a thin layer upon a white plate. In examining these films it was obvious to me that the small air bubbles were in no case attached to the mineral, but were held suspended in the mass of the viscous oil used.

Q. 91. Have you been continuously acting in a professional capacity for Minerals Separation, Limited, up to the present time?

A. I think, without intermission, since the beginning of 1905. Also for a period before that time, with about six months' interregnum.

1642 Q. 92. In conducting the operations with the different machines for demonstrating the process of patent 835,120, and particularly in the supplying of oil thereto, as set forth in your answer to question 79, what means did you adopt for the purpose of adjusting the quantity of oil to an amount equal to a fraction of one per cent. on the ore?

A. In continuously acting plant the rate of feed of the ore was known and the amount of oil requisite to give a fraction of one per cent. upon the ore was calculated; the oil was contained in a reservoir above the first agitation mixer, which reservoir was provided with an accurately ground tap; this was then turned and the number of oil drops necessary to give a certain volume in a graduated measure temporarily placed beneath it, was counted. When the number of drops was in accordance with the amount of ore to give the required proportion, the tap was left turned to that extent, the graduated measure was withdrawn, and the ore supply and liquor started. In smaller demonstration froth plant, such as the bottle or slide machine, the oil was added in the requisite number of drops by means of a pipette or dropping tube.

Q. 93. What measures were adopted in the continuous machine for feeding the ore at a constant rate?

A. Mechanical types of ore feed were adopted, such as are well known in practice, such as the belt conveyor, combined with a hopper, whose discharge apex nearly touched the belt; at a given speed of travel of the belt a uniform quantity of ore was delivered to the mixer, provided the hopper was kept filled, and this amount could be determined with fair accuracy.

Q. 94. Will you describe, in detail, the complete operation as performed in a bottle, as referred to by you in your answer to question 92?

1643 A. A weighed amount of powdered ore crushed to suitable fineness was mixed in a bottle with about four times its weight of water. Sulphuric acid was added until the pulp had definite acidity, such acidity being below one per cent. of the pulp. The requisite quantity of oil, namely, a fraction of one per cent. upon the ore, was then added by means of a pipette. Sufficient space was left in the bottle to include a substantial amount of air or free space above the pulp level. The contents of the bottle were then warmed by immersion in a warm water bath until a temperature of about 40° Centigrade was reached. The bottle was then closed by a tightly fitting cork and the contents shaken for some minutes with considerable violence by hand. The agitation was stopped, when on placing the bottle upright and keeping it stationary a thick froth of mineral rose to the surface, when the sands that sank to the bottom of the vessel were visually deemed to be sufficiently depleted of mineral, and when the gangue slimes, still in suspension in the liquor, showed by their color or whiteness that the slimed mineral had also been removed into the froth. Different degrees and times of agitation would be necessary with different ores and with varying oils. The temperature might also be varied and the amount of acid necessary to produce sensible acidity would also vary with the nature of the ore constituents.

The removal of the froth from the bottle was not so easy a matter, quantitatively. It could be done to some extent by floating off the froth by addition of water through a funnel, but special types
1644 of apparatus were evolved by us to ensure a better collection of the froth.

Q. 95. What characteristic of the ore constituents would necessitate varying the amount of acid to produce sensible acidity?

A. Any substance present in the ore which would combine with sulphuric acid, such as metallic or alkaline earth oxides, hydrates, carbonates, or, in fact, any substance decomposed by highly dilute sulphuric acid.

Q. 96. In other words, if I understand you, in order to produce the necessary sensible acidity it would be necessary to add enough acid to react with the substances you have mentioned in order that some free acid might remain; am I right?

A. Certainly, with acid of that dilution.

Q. 97. Do you remember who took up the question with your pat-

ent solicitors of making application for U. S. patent 835,120 in suit, whether yourself, Mr. Ballot, Mr. Picard, or whom?

A. I think we all three of us saw Mr. Ballantyne on the matter.

Q. 98. Did you ever see an apparatus in the laboratory or works of Minerals Separation in which there were a series of spitzkast or spitzlutte, the first having the pulp delivered to it over an apron or launder leading from the agitator, the first spitzkast delivering froth or float material of some kind over its upper edge and delivering ore still containing some valuable mineral from its lower point upon an apron leading into the second spitzkast, and so on through a series of three or four spitzkast. Such an apparatus was
1645 described in an article in the Engineering and Mining Journal, dated April 30th, 1910?

A. I do not recollect such an apparatus.

The Commissioner notes that a copy of the article referred to was handed to the witness.

Q. 99. Was the copy of Mr. Higgins' report, referred to in Sulman and Picard's report of March 3, 1905, accompanied by a letter from Mr. Ballot?

A. There would be no necessity for a covering letter, as we were seeing Mr. Ballot daily, and he may have handed me the report personally, but from the opening sentence of our report I acknowledge the receipt of this copy with curve diagrams, which makes it possible that it was sent around to my office by hand, with a covering letter. Mr. Ballot always required us to acknowledge receipt of documents, but I have no recollection of any covering letter.

Q. 100. Were the seven instructions summarized in Sulman and Picard's Report of March 3rd, 1905, conveyed to Mr. Higgins in writing?

A. Yes, in this manner: Mr. Ballot, Mr. Picard and I had several consultations shortly prior to this time, and jointly determined upon the list of factors to be investigated. These were written out by myself in consultation, and in the presence of Mr. Ballot, and, I think, Mr. Picard, and were handed to Mr. Higgins either by myself or Mr. Ballot.

Q. 101. Can you produce these instructions which were given to Mr. Higgins?

1646 A. No, I cannot.

Q. 102. Have you a copy of them?

A. No, I have no copy.

Q. 103. Where were you and Mr. Ballot and Mr. Picard when this consultation took place?

A. My memory is that it was at our offices at 44 London Wall.

Q. 104. You are not sure whether Mr. Picard was present or not?

A. I know Mr. Picard was present at the consultation when the factors to be investigated were mutually agreed by all three of us. I am not sure whether he was present when these were written out by myself.

Q. 105. Have you ever seen any flotation concentration process,

whether an oil process or not, in actual commercial use, as distinguished from demonstrations, tests and experiments?

A. I do not recall having seen any flotation concentration process in actual commercial use, if this means witnessing the running of a plant—at a mine, but I have seen large scale runs made in commercial size apparatus at Minerals Separation works and in the Elmore oil buoyancy plant.

Q. 106. It is a fact, is it not, that in actual mill operations at a mine or any place where ore is being practically concentrated, the rate of flow of the ore-containing pulp varies from time to time, and that the ratio between the water and ore in the pulp is also a varying factor?

A. That is so to a certain extent; the variations would to
1647 some extent be accidental, as in all concentration processes it is necessary for their best work that uniformity of conditions should be observed and precautions, in all well regulated plants, are taken to secure such uniformity.

Q. 107. In operating with the process which patent 835,120 in suit purports to set forth, did you devise any means for maintaining the amount of acid and oil relative to ore set forth in that patent when operating upon the pulp flowing at a varying rate, and containing a varying percentage of ore to water?

A. In the plant devised to give effect to the process described in the patent in suit at the experimental works of Minerals Separation, there were no difficulties in obtaining uniformity of pulp, of ore supply, and, therefore, of ratio of ore to liquor. In these cases, owing to the fact of the location of plant in London, the ore was dry crushed, and hence could be measured with fair accuracy and proportioned to water in such a manner as to insure uniformity.

Q. 108. You never had an opportunity, then, I assume, for attempting to apply the process under ordinary operating conditions where the rate of flow of pulp varies from time to time, and where the ratio of ore to water in the pulp also varies from time to time, and often, as I understand, with quite great irregularity?

A. Personally I have had no occasion to apply this oil concentration process to conditions that you have named, but it does not occur to me from my experience in cyaniding on a large scale, that there would be any difficulty in applying well known types of ap-
1648 paratus to insure such uniformity of condition as is necessary.

Adjourned to Thursday, August 8th, 1912, at 10:30 A. M., at the same place.

London, August 8th, 1912.

Met pursuant to adjournment. Present, counsel as before.

Direct examination of Henry Livingstone Sulman continued:

Q. 109. Referring to your references to the launder or tray, corresponding to that indicated by the letter O, in the patent in suit, will

you state whether the process operated to produce a better froth when the launder was used, or in the latter apparatus in which the launder was dispensed with?

A. I could not definitely say, for this reason: The launder was practically a continuation of the flow of liquor from the last agitator to the still surface of the spitzkast. The liquor flowing down it was therefore in motion, and no froth could form there, the necessity for the formation of a froth being a comparatively quiet water surface or mass, which the froth can rise through without interruption. No froth formed, that I can remember, in the launder, but it built up on the surface of the spitzkast as close to the launder as the flow of liquor permitted. We obtained good froths on the spitzkast in this way of the type that was termed by us a mat froth or a cauliflower froth, amounting in thickness to one or two inches.

1649 Sometimes, to my memory, even more. The surface of our spitzkasten was rather large at first, and by diminishing this area we found we could pile the froth up to a greater thickness. The gradual elimination of the tray or launder was contemporaneous with a restriction of the spitzkasten surface. In the latter types of froth separators, which embodied both these factors, we certainly did obtain a thicker piled up froth, but it is difficult to say how far this was due to the elimination of the tray or launder, or to the restriction of the spitz surface. As I mentioned yesterday, one object of the launder was to give the coarse oiled mineral particles in the pulp which might not be caught in the froth initially a chance of floating at the water surface contemporaneously with the formation of the froth in the spitz box.

Q. 110. Will you kindly, for the purpose of making our terminology clear, distinguish between what I think has been referred to by us as "froth flotation" and "film flotation"?

A. We have generally confined ourselves in speaking of froth to the specific type of froth produced by the process described in the patent in suit. This froth consists of an assemblage of bubbles of air, with some traces, perhaps, of other gases, but mainly air, the bubbles being of varying sizes from exceedingly minute ones to quite large bubbles. The liquor surfaces of these bubbles are highly contaminated and associated with the slightly oiled mineral. The mineral particles are of all sizes, from the finest slime mineral

1650 up to particles of sensible size, say, 60 mesh, sometimes even coarser. The slime mineral particles appear to be closely associated with each other and with the larger particles, at times, in the form of spongy flocks, the whole mineral being so intermixed, as regards its varying sized particles and flocks and with the air bubbles, as to form coherent froth of somewhat spongy nature. The nature of the froth varies somewhat with different minerals, but all have the same specific matted, coherent and persistent characters when the plant and process are operated to their best purpose and effect. The froth so obtained when broken down by mechanical means or by draining results in a deposit of the mineral particles, which exhibit to the touch and upon inspection no visible traces of oil, and one would not suspect the presence of oil therein unless an

analysis were made. One essential for such a froth is the inclusion therein of slime mineral, as without the aid of such fine material our experience is that the specific agitation froth we obtain normally cannot be formed.

Q. 111. In the prosecution of the applications for patents in various countries upon the subject-matter of the United States patent 835,120 in suit, were you and Mr. Picard and Mr. Ballot all consulted regarding the various steps necessary from time to time; I mean, as obstacles or objections arose, as they might have arisen, to the grant of such patents, were you and Mr. Picard and Mr. Ballot consulted as to the responses to be made to the various Patent Offices?

A. Doubtless we were all three in close consultation with
1651 our patent agents in all these matters from first to last.

Q. 112. Do you remember of having been consulted in regard to the prosecution of an application for a German patent upon this subject-matter?

By Mr. Williams: Objection is made to any reference to an application for letters patent in Germany, as wholly irrelevant to any of the issues in this controversy.

A. I have a broad memory that we were consulted on all matters in connection with grants or objections to grants of patents in various countries, and I have a memory that some such consultations took place in reference to the German grant, but I should require to refresh my memory before I could recall any details of this.

Q. 113. Regarding the prosecution of this application for a German patent upon the subject-matter of the United States patent in suit, is your memory clear upon the ultimate issue of that prosecution, namely, as to whether such a patent was finally obtained and permitted to remain in force?

By Mr. Williams: In view of the fact that the matter referred to is utterly irrelevant to the issues of this suit, and is further a matter of public record, as to which the documents will speak for themselves, the witness is directed to confine his answer to an affirmation or denial as to whether or not he remembers the matter inquired of in the question.

1652 A. I really don't remember.

Q. 114. Do you mean, by this answer, that you distinctly affirm that you do not remember whether or not a German patent was granted upon the subject of the United States patent here in suit, and that you do not remember whether or not such a patent, if granted, was permitted by the German Patent Office or court to remain in force?

By Mr. Williams: Same instructions.

A. I do not remember that a German patent was granted to us.

Q. 115. Do you remember that a German patent was not granted upon the subject-matter of the United States patent here in suit?

By Mr. Williams: Same instructions, it being noted that the objection is included in the instructions.

A. This is now my impression and belief.

Q. 116. Do you remember that application was made for a German patent upon the subject-matter of the United States patent here in suit?

A. I do.

Q. 117. In carrying out the process which the United States patent in suit purports to disclose, is it necessary in operating upon a flowing pulp, having an irregular rate of flow, and carrying a varying amount of ore, and possibly carrying ores of varying degrees of richness, that some means should be adopted for controlling
1653 the feed of oil to the pulp whereby the operator, conducting the process, might assure himself that at all times he was feeding the percentage of oil to ore prescribed in the patent in suit?

A. Naturally, under non-uniform conditions, means should be adopted for controlling the regulation of any of the ingredients, whether oil or acid, in order to obtain the desired effect, that is, the production of an agitation froth.

Q. 118. Would it be necessary to make the adjustment of the quantity of oil relative to ore quantitatively, that is, by the use of measuring or regulation feed devices whereby the operator might be assured of maintaining the proper quantitative ratio between the different ingredients, that is, the percentage ratio set forth in the patent?

A. Naturally, and this is the reason why the reservoirs containing the various ingredients necessary are furnished with taps to regulate the additions to the ore, as specified in the patent in suit. Obviously the first essential towards carrying out the instructions as to the proportions given in the patent is that one should know the quantity of ore being delivered to the concentration plant. If these ore supplies are irregular, from external causes, over which the operators of the concentration plant have no control, the necessary regulations would have been determined as to the amount of ore sent to the concentration plant. The same broad requirements would apply to any system of concentration, whether by oil or the ordinary
1654 water concentration methods, and, indeed, to any continuously acting process where a certain range of conditions is necessary.

Q. 119. As I understand you, to state it briefly, the operator of the process, in order to maintain the proportions of oil and acid to ore, as set forth in the patent in suit, naturally must be informed as to the amount of ore, which he is treating, in order to maintain the proportions referred to; am I right?

A. It is, of course, well that he should be informed of this, or should take such steps himself as would enable him to apply the agitation froth process described in suit, under these of any similar abnormal conditions. The adjustment of the oil, even under such abnormal conditions, is, however, very easily effected, because the phenomenon of the agitation froth production is in itself an indica-

tion of the right amount of oil to employ. If, therefore, it were not convenient to quantify the ore supply from time to time, it would be quite easy and effective to slightly vary the oil addition to the incoming pulps in order to produce the maximum agitation froth formation. This method of regulating the oil supply we might call a synthetic mode of regulation as compared with the more analytic method of adding known quantities of oil to a previous quantified ore supply.

Q. 120. Then, it might be, that an operator following what you have termed the synthetic mode of regulation might not know whether he was adding oil or acid within the proportions set forth in the patent in suit?

1655 A. It might be so, for the space of a minute or two; as to the acidity, this can be determined instantly by means of Litmus paper, or other suitable indicator, it only being necessary to have a slight degree of acidity present in the pulp. As to oil, the proportions specified in the patent do not need extremely fine adjustment. When the generally minute quantities of oil to ore are considered, which amount in practice, roughly, to about two pounds per ton of ore in a great number of cases, or perhaps somewhat less or more, conditions of ore supply may fluctuate to some extent without greatly affecting the result. If these fluctuations in supply are excessive then the operator would naturally make such further slight adjustment of his oil addition as would meet the altered circumstances.

Q. 121. You have stated that the amount of oil used in this process approximates two pounds to a ton of ore. Can you make a similar approximation regarding the amount of acid?

A. No. This will be determined for each particular ore and run of ore by experiment. Thus, ores which contain calcite will require more acid than ores which contain none, and rough approximation would be made experimentally upon an average sample of the particular ore in question. Thereafter, the rough quantity having been determined the pulp will be regulated as to a sufficiency of acid by Litmus paper or some such means.

Q. 122. I invite your attention to the drawing of United States patent 787,814 granted to J. D. Wolf on April 18, 1905, and

1656 inquire whether you ever used an agitating or mixing apparatus similar to that shown at the left hand of that drawing?

By Mr. Williams: Objection is made to any reference to this Wolf patent No. 787,814 as incompetent, for the reason that the patent is not set up in the answer and is irrelevant to any of the issues herein.

A. Yes; I have seen the apparatus to which my attention is drawn and have seen it in operation at Mr. Wolf's works. It was used in connection with an oil buoyancy process wherein thick viscous oils were used to entrap and buoy up mineral particles in the same general manner as the Elmore process. The object of this agitator was to disseminate the thick oil in globules of sensible size through the pulp in order to bring them into contact with and thus to entrap metallic particles in suspension in the water beneath the oil. The

globules of oil then rose to the surface with any entrapped mineral by the buoyancy of the oil, and the mixed floating oil, with its entrapped mineral, and water, were then discharged into a pointed box wherein the separation of mineral and oil from sunk gangue was started.

Q. 123. You have stated in answer to question No. 119 that if it were not convenient to quantify the ore supplied from time to time it would be quite easy and effective to slightly vary the oil additions to the incoming pulps in order to produce the maximum agitation froth formation. In operating according to this method the operator would be guided, would he not, by the results secured
1657 rather than by the maintenance of any known quantitative relations between the different materials?

A. That is what I meant, the result to be obtained being the production of the specific agitation froth required.

Q. 124. Can you remember approximately the date when you saw the apparatus shown at the left hand of the drawing of the Wolf patent which I have referred to?

A. My memory is that it would be some time shortly before the date of the application for this patent.

Q. 125. After you learned of the existence of the Froment British patent in August, 1903, did you direct the attention of the gentlemen who were then, or subsequently became associated, in Minerals Separation, Limited, to that patent?

A. I at once drew their attention to the abstract of the Froment patent published in the Journal of the Society of Chemical Industry about that date.

Q. 126. And yourself and these gentlemen were so favorably impressed with the Froment patent, were they not, that they acquired it, and it is now owned by Minerals Separation, Limited, is it not?

A. Answering the latter portion of your question first, the Froment patent rights are now owned by Minerals Separation, Limited. With regard to the first part of your question, Mr. Picard, Mr. Cattermole and I had already been working on these lines, but from the abstract referred to it was evident that in sundry par-
1658 ticulars Froment had antedated us, and the gentlemen who were interested with us in our previous work and in the Cattermole process decided to acquire the Froment patent.

Q. 127. What was the first occasion, Mr. Sulman, upon which you ever saw the valuable constituent of a mineral floating as a froth upon a freely flowing pulp or suspended upon the surface of the pulp in the form of bubbles?

A. My impression is that it was during the experimental investigation of the Cattermole process in my firm's laboratory. I can no doubt give you approximate dates by referring to some of my firm's reports on the Cattermole process.

Q. 128. I do not care for the exact date, but I assume from your previous testimony that this occurrence was earlier than the year 1905.

A. Certainly. I think it would be between the end of 1902 and the middle of 1903. In this connection the float material noticed

was in the shape of Cattermole granules now and again floated by surface tension effect to the top of the upcast separator instead of their normal sinking to the bottom of this separator. This occurrence was by no means a froth. My first memory of anything approaching to a mineral froth was towards the middle of 1903, when carbonic acid gas was chemically generated in a pulp containing mineral oil in the Cattermole proportions.

Q. 129. In your answer to question 22 you have stated that the gabbet apparatus contained suitable baffles. What was the
1659 function of these baffles?

A. The function of the baffles was to give the agitation, normal to the Gabbet apparatus, of which they form an integral part.

Q. 130. Were these baffles used in the operation of the Cattermole granules precipitation process?

A. They were invariably used during the first portion of the Cattermole granulation where it was necessary to agitate the oil and the mineral to the extent required to uniformly coat the mineral particles with oil. They were not used in the second portion of the process referred to, where it was desired to roll these oiled particles into coherent granules.

Q. 131. Would the use of baffles have been inimical to the carrying out of the second stage of the Cattermole process.

A. Yes. They would have prevented the building up of the shot-like granules desired in the Cattermole process.

Q. 132. But as I understand it these baffles assisted the operation of the froth process at all stages?

A. Certainly.

Q. 133. What effect did these baffles produce in the froth process which would not have been secured by the rotation of the cone gabbet in the cylindrical vessel not provided with baffles?

A. They produced the violent agitation and the entraining of air necessary to float mineral as a froth when quantities of oil were used insufficient for granulation.

1660 Q. 134. I assume from the explanation you have given that when a square vessel is used with an agitator provided with radiating arms, the non-circular character of the vessel and irregular form of the rotating body in a measure dispensed with the necessity of independent baffle members?

A. That is so.

Q. 135. In the Cattermole process, that is, in the second stage referred to by you, where the cone gabbets rotated in a cylindrical vessel not provided with baffles, I presume the movement communicated to the liquid and referred to by you as a rolling movement, I think, consisted largely in a mass rotation of the body of liquid in the vessel?

A. That is substantially correct.

Q. 136. Will you describe the kind of action which takes place when the baffles are used, that is, the sort of movement communicated to the liquid?

A. The normally rotating liquor mass is thrown against the baffles, producing eddies and much more agitation of the liquor mass,

and of the particles contained in this mass, than when merely rotatory motion was given to the whole. The particles in suspension were changed in relation to one another when hindered by the baffles more than would be the case when they were uniformly rotated in the suspending liquor.

Q. 137. In the presence of baffles in the gabbet agitator I presume the surface of the liquid becomes more broken and turbulent?

A. Quite so.

1661 Q. 138. Thus promoting the entraining of air?

A. That is so.

Q. 139. In your answer to question 110 you refer to the bubbles composing the froth as containing air and other gases. Will you state what other gases besides air are found in the froth?

A. The other gases besides air which I have referred to as being in very small quantity, and not necessarily present, are carbon dioxide and very occasionally traces of sulphuretted hydrogen. The carbon dioxide is the more common of the two and is met with in agitation froths derived from mineral which may contain no trace of carbonates or materials which would generate carbonic acid in contact with sulphuric acid. The presence of carbonic acid in such cases is accounted for by the oxidation of the minute oil films on the surface of the mineral by means of the air films attached thereto.

Q. 140. I presume in treating ores containing a considerable amount of easily decomposed carbonate there will be a larger amount of carbonic acid gas than in the treatment of ores containing less carbonates? Is that correct?

A. I do not think it necessarily follows to a substantial degree. The agitation operation requires a certain period before the oil is disseminated over the mineral particles and during this time the carbonates, which were decomposable by the dilute acid employed, would have been decomposed and large quantities of air would have been beaten into and out of the mixing vessel before an op-

1662 portunity were given for the froth to form. Very considerable proportions, I should think the major proportion, of the carbonic acid so generated would have been eliminated in the mixing vessel. I state this fairly broadly, and I should expect to find rather more carbon dioxide in the froth derived from a mineral containing calcite than from one which did not contain calcite. I should not, however, regard the presence of carbon dioxide in the froth as an essential concomitant but rather as an accidental inclusion therein.

Q. 141. When did you first meet Mr. Hyde, the defendant?

A. I have not had the pleasure of meeting Mr. Hyde before I appeared as a witness in this case.

Q. 142. Do you remember of ever having had any correspondence with Mr. Hyde?

A. I do not remember any correspondence with Mr. Hyde.

Q. 143. You have referred to the fact that you and Mr. Picard were developing or working upon a flotation process at the time you first learned of the existence of the Froment process. Is the process which you and Mr. Picard were then occupied upon, the one set forth in

United States patent 793,808 granted to yourself and Mr. Picard July 4, 1905?

A. That is the only flotation patent that Mr. Picard and I worked at alone, but there was another flotation process about the same time in which we were also concerned with Mr. Cattermole, United
1663 States patent No. 788,247.

The Commissioner notes that copies of the several documents produced by the witness and marked for identification have been handed to defendant's counsel.

Direct examination closed.

Cross-examination.

By Mr. Williams:

X Q. 144. Please state generally your experience as a metallurgist, including your education and your associations in that art.

A. I am past president of the Institution of Mining and Metallurgy and a fellow of the Institute of Chemistry, Great Britain. I am also a member of the Society of Chemical Industry and of several other technical societies. I received my chemical and metallurgical training at University College, London, where I devoted four years to the study of these subjects. I was awarded the gold and silver medals for practical and theoretical chemistry, respectively, and the bronze medal for fuel and metallurgy. Since leaving college in 1881 I have been engaged exclusively in the practice of the profession of technical chemistry and metallurgy and since about 1891 I have been exclusively engaged in metallurgical work. I have traveled in connection with my metallurgical work in South Africa, Australia, The Malay States, Japan, Canada and the continent of Europe. I have had considerable experience in the treatment of various
1664 ores, gold silver, copper, lead, zinc, etc., and am well acquainted with the general processes used for extracting these metals from their ores. I am also conversant with methods for concentrating ores and have given particular attention, of late years, to the concentration of ores by means of oil.

X Q. 145. Exclusive of your inventive and investigating work for Minerals Separation, Limited, one of the complainants, have you been consulted as a metallurgist and have you made inventions relating to metallurgical subjects? If so, please briefly outline this work.

A. I have. I am the co-inventor with Dr. F. L. Teed of the bromocyanide process, a modification of the cyanide process, which has been extensively used, and is still being used in Australia for the reduction of refractory gold ores. This process has already successfully treated about 5,000,000 tons of refractory telluride ores in Western Australia and other refractory ores elsewhere. I have also co-operated with Mr. Picard in developing and perfecting his invention for the reduction of refractory zinc-lead ores by what is known as the briquetting process. I am the inventor of a process for treating refractory

lead-zinc ores by a wet process with the aid of sulphurous acid. I also invented a method for converting the dry ball-mill into a wet crusher and this invention has been used by Messrs. Krupp of Germany for many years past.

X Q. 146. By what concerns have you been consulted as to oil concentration processes?

1665 A. I have been consulted in relation to a float gold process, of which I was also the inventor, which was devised for the purpose of avoiding losses of gold as float material by a method of reducing the surface tension of the milling water, and also in regard to the precipitation and coagulation of slime material from milling water by means of a soap solution. This was in 1893 and 1894. I have also been consulted by the inventors of the Robson and Crowder oil process, also by clients in regard to the Elmore oil process, who were investigating the latter, with the object of working it in a British colony. I have also been consulted with regard to the Cattermole, Froment and other processes which are antecedent to the patent in suit as to date, and I am generally cognizant with the details of other oil processes which have been invented of late years, including that of Wolf, by whom also I was consulted.

X Q. 147. Your attention was directed to an agitating or mixing apparatus shown at the left-hand of the drawing of United States patent to Wolf, No. 787,814, this apparatus being generally designated by the letter B. What can you say additionally as to that mixing apparatus, its origin, and knowledge of it in the metallurgical art?

A. This was a type of apparatus which was well-known at the date of Wolf's patent. It was built and sold by Messrs. Johnson of Stratford, manufacturers of industrial machinery, filter presses, etc.

X Q. 148. Please briefly describe the construction and op-

1666 eration of this apparatus which I believe I may term the "Johnson mixer."

A. It is a cylindrical mixing vessel with a hemispherical bottom and contains a central tube rigidly supported by a series of radial arms. Within this tube is a rotating vertical shaft, at the bottom of which are a series of impeller blades. According to the direction of the rotation of this central shaft and impeller, the liquor in the containing vessel would either be forced up the central tube and out at the top, so forming a circuit in one direction, or the liquor might be drawn down the tube, and expelled at the bottom, returning again over the top of the central tube. The apparatus was designed to produce much the same effect as the apparatus generally known as a gabbet or cone mixer. In this instance the radial arms supporting the inner tube acted as efficient baffles, preventing the undue rotation of the liquid mass as a whole.

X Q. 149. You have said that this Johnson mixer was well known at the time of the Wolf patent. I note that the patent was issued in April, 1905, upon an application filed in May, 1903. Did you intend to include one or both of these dates in your answer?

A. I intended the earlier date.

X Q. 150. You have mentioned an apparatus generally known as a gabbet or cone-mixer. Will you please describe this apparatus?

Mr. Scott: The question is objected to as implying contrary to anything that has been proved in this case that the term "gabbet" is a well-known term or conveys any definite meaning.

1667 A. The apparatus which is known to me, and generally to metallurgists, as a gabbet or cone-mixer, is that which is described in the British letters patent No. 840 of 1889, granted to Boulton, Haywood, Boulton and Gabbett, and the apparatus is generally known by the name of the last of these inventors. It was an apparatus well known in the industrial world and figured upon the covers of technical journals. It consists of a containing vessel fitted with a central shaft which carries a truncated hollow cone which may be either upright or inverted. The cone may be varied in shape and may contain internal baffles. The containing vessel, in which the cone is rotated, producing a centrifugal ejection effect from the larger diameter of the truncated cone, may be either cylindrical or square. If cylindrical, it is suitably fitted with stationary baffles. This type of apparatus was well known to me for many years previous to its application to the Cattermole process and was used by me and in my laboratory for the agitation and aeration of cyanide pulps.

I should say in connection with this apparatus, that the apparatus as a whole, and not merely the rotating cone, is known as the gabbet or cone-mixer.

X Q. 151. In your answer to Q. 16 you mention a small scale plant which you were instrumental in designing and erecting and which was sent out to Australia, this plant being for the operation of the Cattermole process. Can you produce a photograph of this plant and if so, will you do so?

A. I can, and will.

1668 The Commissioner marks for identification a photograph produced by the witness in answering the last question as "Photograph Australian Cattermole Plant."

X Q. 152. I note that upon this photograph there are red ink markings of a descriptive nature. By whom, if you know, was this marking made?

A. These markings are in my own handwriting.

X Q. 153. Please briefly describe the plant shown in this photograph?

A. The plant consists of a battery of mixers which consist of vessels formed of metal at the bottom and glass at the top. These mixers are arranged in three series, and each is fitted with an internal revolving cone. The top series of four and the second series below of three mixers are gabbet mixers. That is to say, they contain wire baffles which are essential to the cylindrical form of this mixer and are designed to perform the agitation necessary in the first portion of the Cattermole process. The lower mixers contain no baffles and I think Nos. 5 and 6 mixers of the second series do not contain baffles

and were therefore not the normal gabbet mixer. It was in the mixers without baffles that the rolling motion was given to the pulp.

X Q. 154. Please now produce the reports of your firm relating to the plant which you have just described.

A. I now produce these reports dated November 19th, 1903, and March 4th, 1904.

1669 X Q. 155. By whom are these reports signed, and to whom were they delivered?

A. They are signed by my firm in my handwriting, and they were delivered to Mr. John Ballot.

The Commissioner marks for identification the reports produced by the witness as "Sulman and Picard Report, November 19, 1903," and "Sulman and Picard Report March 4, 1904," and copies of these reports are handed to defendant's counsel.

X Q. 156. In the work done by you for Mr. Ballot and those associated with him, first in the Cattermole Ore Construction Syndicate, Ltd., and afterwards in Minerals Separation, Limited, what was your habit as to making a record of the work done for these concerns?

A. No matter how closely we collaborated and how intimately all the experiments were known to those concerned, Mr. Ballot always insisted upon such results being put into complete form as a record of work done, and this was always carried out by us.

X Q. 157. Please produce reports of this nature other than those you have heretofore produced, describing them by the respective dates of the reports.

A. I now do so, and describe the reports as dated 25th March, 1903; May 5th, 1903; September 24th, 1903; April 19th, 1904; May 2nd, 1904; May 18th, 1904; 17th February, 1905; 21st February, 1905. As to the report of May 5th, 1903, the document

1670 produced is a copy from our own file, the original report having been mislaid or lost.

The several documents produced by the witness are marked by the Commissioner for identification each as "Sulman and Picard Report," followed by the date appearing on such report.

X Q. 158. You have said that the plant shown in "Photograph Australian Cattermole Plant" was sent to Australia. Who, if anyone went with it to Australia?

A. Mr. George Chapman, to whom a copy of the photograph was handed.

X Q. 159. You were asked in Q. 49 whether you built any other apparatus than an apparatus substantially like that shown in Figure 1 of the patent in suit, at a later date, for the purpose of operating the process of the patent in suit. Did your answer to that question include small scale or testing apparatus?

A. No, my answer contained no reference to small testing plant or apparatus.

X Q. 160. Please now describe the several constructions of

small scale or testing apparatus, such as that question would call for.

A. In small scale testing work with small quantities of ore it was not practicable to float a froth off from the small testing vessel by means of water with completeness. Mr. Picard and I devised several types of apparatus for separating the froth after it had been formed in small scale experiments more effectively. Many types of
1671 apparatus were constructed by us, such as vessels provided with a movable septum, either of celluloid or cloth which might be drawn beneath the froth after this had collected at the surface of the liquor and after the gangue material had subsided. These methods answered better, but we found the best method was to cut the froth portion of the pulp from the gangue portion of the pulp by means of sliding the top portion of the vessel away from the bottom portion upon a suitably constructed slide device. The first type of such apparatus which I made at Cowper street was a block of wood divided longitudinally into three cuts; the bottom portion or cut formed the bottom of a series of vessels which were formed by boring a large hole through the two upper cuts. The two surfaces were then greased and fitted together and formed a series of water-tight vessels. The froth-forming pulp was now filled in these vessels and allowed to stand until the froth had fully formed and the gangue had subsided. Upon now pushing or sliding the upper wooden cut or portion of the apparatus, the froth-bearing liquor was sliced off in entirety and was collected in a vessel placed at the side of this device. This rough apparatus answered so well that we devised a glass and metal agitation vessel for performing the same action with accuracy and efficiency. Two or three of such apparatus were constructed by Mr. Picard and I am able to produce the first of these which fulfilled all the necessary requirements.

X Q. 161. Please produce the apparatus referred to.

1672 A. I do so. This apparatus was described by us in a report to Mr. John Ballot dated 24th February, 1910, of which I produce a carbon copy of the original from our files. This apparatus was shown by us to Mr. Theodore J. Hoover.

The Commissioner marks for identification the apparatus produced by the witness as "Sulman and Picard Slide Machine" and the report produced by the witness as "Sulman and Picard Report February 24, 1910."

X Q. 162. When relatively to the date of this report February 24, 1910, was the apparatus "Sulman and Picard Slide Machine" made?

A. This particular apparatus was made some little while before, and had been tested by us, but others of the same type had been previously made and experimented with and it was not until we got the results that this improved type gave us that we reported the matter to Mr. Ballot. We were engaged, I suppose altogether, about two or three months previously constructing apparatus which led to this.

X Q. 163. Referring now to your answer to Q. 133, please state whether or not you are prepared to say that with an apparatus like

the cone mixer or gabbet, but modified by the omission of the stationary baffles, an agitation froth such as you have repeatedly referred to cannot be produced.

A. I am quite unprepared to say this.

Adjourned to Friday, August 9th, 1912, at 10.30 A. M., at the same place.

1673 London, August 9th, 1912.

Met pursuant to adjournment.

Present: Counsel as before.

Cross-examination of Henry Livingstone Sulman continued:

X Q. 165. Have you had a search made for any letter such as as referred to in Q. 99, and if so, with what result?

A. I have, and produce two letters dated March 3rd, 1905, and March 6th, 1905, each signed by Mr. A. O. Williams, Secretary of Minerals Separation, Limited.

The Commissioner marks for identification the two letters produced by the witness respectively as "Minerals Separation Letter," followed by the date of each letter.

X Q. 166. You have produced a number of reports signed by your firm and each one dated. What does the date of each of these reports signify?

A. I dated each report on the day that it was written and it was immediately delivered to Mr. Ballot.

X Q. 167. In Q. 110 you were asked to define froth flotation and film flotation, and your answer is apparently confined to froth flotation. Please complete that answer by defining film flotation.

A. By film flotation, which is sometimes also referred to by us as skin flotation, is meant the flotation of particles of oiled or unoiled mineral at a water surface by surface tension effect. Such
1674 films would contain the mineral particles in a layer, not substantially exceeding one particle thick. Both oiled and unoiled mineral particles form such films, but the films of oiled mineral are much more persistent than films which are composed of unoiled particles. Such films may occasionally contain isolated bubbles coated with, or contaminated by, such mineral particles, but such occasional bubbles would not form a froth.

X Q. 168. You have said that in a film or skin flotation the particles of mineral are floated at a water surface by surface tension effect. In the phenomenon of agitation froth flotation is, or is not, the phenomenon a surface tension phenomenon?

A. Not in the sense in which I have employed the term in the answer to the last question. In this answer I referred to surface tension effect as that flotation effect which is exhibited at a plain water surface just as a greased needle will float at such a surface. The whole of the phenomena of froth flotation involve physical reactions which might be broadly classed under surface tension

phenomena, but I have not used the words "surface tension effect" to refer to these.

X Q. 169. You have devoted considerable time to studying and experimenting, have you not, in an investigation of the scientific aspect of flotation phenomena?

A. I have.

X Q. 170. What have you found to be the effect of heat in the specific phenomena of agitation-froth flotation?

1675 A. The effect of heat is advantageous to the operation of agitation froth production in two main respects. The first of these and perhaps the lesser effect is the decrease of viscosity of the oil with increased temperature by which it is capable of more ready sub-division and dissemination throughout the mineralized pulp. The second effect of increased temperature is the modification of surface tension effect between the water and oiled mineral surface in the direction of a beneficial effect in the attachment of air thereto.

X Q. 171. What have you found to be the effect of mildly acidifying the water of the pulp in the specific phenomena of agitation froth flotation?

A. Acidified water tends to wet the gangue particles more efficiently than plain water, or water unacidified, and thus prevents the adhesion of oil to such particles to a greater extent than obtained when unacidified water is used.

X Q. 172. Is this a chemical or a physical phenomenon?

A. It is entirely a physical phenomenon.

X Q. 173. What did you find to be the result of heat in such processes as the Elmore, to which you have referred, and also the Wolf process?

A. Both of these processes were bulk oil processes which depended upon the buoyancy of the oil for supporting the mineral entrapped in it. Considerable viscosity of the oil was necessary to prevent the heavy mineral from sinking out of the oil mass too rapidly when so entrapped. The wolf process involved the use of oil made
1676 still more viscous by the use of chloride of sulphur. In both these processes increased temperature led at once to decrease in viscosity and considerably enhanced the tendency of the entrapped mineral to fall out of the bulk of oil in which it had been entrapped.

X Q. 174. How about the effect of violent agitation in the Wolf and Elmore bulk oil processes?

A. If agitation exceeded a certain moderate limit in regard to either of these methods the oil became emulsified in the pulp and a mass of heterogeneous material was formed in which oil, water, mineral and gangue were contained as a "mush." Some of this material might float whilst other portions would sink; no separation of mineral from gangue would be effected, and with violent agitation, the whole mass would form an emulsified product which might be likened to a salad dressing containing ore.

X Q. 175. In your simile of salad dressing, please particularize as to the kind of salad dressing.

A. It would be a unique one. Somewhat of the mayonnaise variety

X Q. 176. I call your attention to Figure 2 of the patent in suit, and ask you whether, or not, in the agitation vessel *a* there shown, an efficient baffle is illustrated?

A. Yes, certainly; it is the stationary baffle marked *a'* in the form of a pipe which would, and did, act efficiently as baffle.

X Q. 177. In your answer to Q. 108, you speak of well-known types of apparatus to ensure uniformity of condition as to pulp
1677 supply. What well-known types of apparatus did you refer to?

A. I referred to the many known types of slime settlers and pulp thickeners which are extensively used for the purpose of de-watering and settling fine ore suspensions for the purpose of obtaining a uniform thickened ore product.

X Q. 178. What, in your opinion, is the best means of determining that the agitation froth process of the patent in suit is being carried on in a large scale plant?

A. The efficient production or realization of the specific phenomenon of the agitation froth.

X Q. 179. In Q. 97 you were asked who took up the question with your patent solicitors of making application for the United States patent in suit. I now ask you the same question as to the making of the application for British patent No. 7803 of 1905, filed April 12th, 1905, a copy of which I now show you.

A. I remember that Mr. Ballot, Mr. Picard and myself took up this question with our patent solicitor, with whom we jointly had many interviews. Mr. Ballantyne, a member of the firm of our patent solicitors, attended for this purpose both at our laboratory, at the works laboratory at Aldermanbury Avenue and at Mr. Ballot's office on several occasions.

Cross-examination closed.

Redirect examination.

By Mr. Scott:

R. D. Q. 180. Do you find that the overflow pipe at *a'*, shown in Figure 2 of the drawing of the patent in suit, is described in
1678 the patent as a baffle, or as having the function of a baffle?

A. It is not so described in the patent in suit, but nevertheless it would have such an effect, as regards the formation of potential froth in the pulp material escaping into the discharge conduit *a'*, so that if this material were directly discharged upon a water surface the agitation froth would form.

R. D. Q. 181. Another effect of heat, which subject you discussed in your answer to cross-question 170, would be to increase the activity of the reaction between the acid used and any carbonates present, would it not?

A. That is so, it would also lead to an increased elimination in similar proportions of such carbonic acid in the mixing apparatus.

R. D. Q. 182. Whenever flotation concentration takes place, in a pulp to which too little oil to float the mineral by the oil buoyancy

has been added, and the pulp has been agitated with the result of raising all of the oiled mineral to the surface as a scum or froth, would you assume that air, beaten in by the agitation had caused or assisted the flotation?

A. This is a very wide question, and would apparently include all quantities of oil below the effective bulk oil limits down to the proportions of oil used in the patent in suit. All sorts of phenomena would take place according to the amount of oil employed and degree of agitation given. Some oil entrapping mineral with entangled air bubbles might result, and in such cases the air
1679 would aid oil buoyancy effects, just as corks caught in a fishing net might enable the latter to float. According to the extent or deficiency of oil, intermediate phenomena would take place, such as the production of "mushes" or of sunken material, but to the extent that oiled material was floated, entangled air bubbles would naturally help to this extent.

R. D. Q. 183. Assuming that flotation concentration has taken place in a pulp to which an amount of oil, equal to two per cent. by weight of the ore, has been added, and the pulp has been agitated, thus producing the flotation, would it be your opinion that air beaten in by the agitation had caused or materially assisted, in producing such flotation?

A. My experience of such conditions as you have named, and with the degree of agitation that I have been accustomed to give, is that granulation would mainly result, and it is not my experience that effective flotation would ensue if the pulp were then brought to rest.

R. D. Q. 184. Is the degree of agitation, which you have referred to in your last answer, some particular degree or duration of agitation?

A. It is of the necessary degree and duration required to bring such quantity of oil into effective contact with the mineral particles present in the pulp.

R. D. Q. 185. Suppose we assume, as set forth in question 183, that under the conditions there set forth, flotation is produced, contrary to your experience though it may be, then would it be your opinion that air beaten in by the agitation had caused, or
1680 materially assisted as an essential factor in producing the flotation?

A. You are asking me to assume something that I have no experience of, all my experiments in such directions being to the contrary effect, namely, that when a pulp so agitated were brought to rest, sinking of the mineral, and not flotation, would result. Indeed, this amount of oil, in my experience, would generally fall within the Cattermole range, and it is only when the oil falls below one per cent. on the ore, and practically to about .5 per cent. upon the ore in most cases, that flotation by such means takes place.

R. D. Q. 186. Was your visit to Australia, to which you have referred, at a date when the process which the patent in suit purports to set forth, was in operation there?

A. No, it was some years prior to that.

R. D. Q. 187. Did you have anything to do with the practical application and development in Australia of the process which the patent in suit purports to set forth?

A. Very little, if any.

R. D. Q. 188. Will you please state what your professional or business connection with Minerals Separation, Limited, is at present?

A. I am their consulting metallurgist, with Mr. Picard, and am engaged in investigating and researching upon the various scientific points which arise in connection with this, and similar processes, and also in answering or helping in such metallurgical ques-
1681 tions as may arise in connection with the process from time to time.

Redirect examination closed.

Recross-examination.

By Mr. Williams:

R. X Q. 189. In R. D. Q. 180 you were asked as to the description of the part *a'* which you have referred to as a baffle. Considering the specification of the patent in suit, without any reference to the apparatus described or shown in the drawings, in your opinion would a metallurgist at, say, the early part of the year 1905, be sufficiently informed by such description of the process, exclusive of apparatus, to carry out the agitation froth process described in the patent?

A. In my opinion he would be fully informed.

Re-cross examination closed.

Deposition closed.

HENRY L. SULMAN.

1682 HUGH FITZALIS KIRKPATRICK-PICARD, a witness produced on behalf of defendants, having been duly cautioned and sworn, testifies as follows:

Direct examination.

By Mr. Scott:

Q. 1. What is your name, age, residence and occupation?

A. Hugh Fitzalis Kirkpatrick-Picard; age 41; residence, 298 West End Lane, Hampstead, London, N. W.; I am by profession a consulting metallurgist and assayer, and my place of business is Sulman & Picard, 44 London Wall, London, E. C.

Q. 2. Are you the Hugh Fitzalis Kirkpatrick-Picard named as one of the grantees of the United States letters patent No. 835,120, involved in this suit?

A. I am.

Q. 3. Will you state, Mr. Picard, when you first learned of the use of oil or fatty matter as a means of separating part of the constituents of an ore by flotation?

A. My earliest recollection would be about 1898. I cannot say

closer than that, and in that answer I refer to my knowledge of the Elmore buoyancy process.

Q. 4. And when did you first learn of the joint action of oil and a gas concomitantly acting to produce flotation of part of an ore?

A. I learned of its use as an accidental concomitant during our work on the granulation Cattermole process about 1902, wherein some of the granules were occasionally, accidentally floated by air.

1683. Q. 5. And when did you learn of the intentional use of oil and a gas to produce flotation of the constituents of an ore?

A. I think that would be in the latter part of 1903 or early in 1904. I know it was some few months' time prior to our first ascertaining the existence of the Froment process.

Q. 6. And I presume the intentional use of oil and a gas, to which you refer, is to some extent at least set forth and described in United States patent 793,808, granted to Mr. Henry L. Sulman and yourself, July 4, 1905, upon an application filed October 5, 1903, copy of which patent you have before you?

A. Yes, and I see by this date that in one of my previous answers I put my knowledge a little too late. I must have first known of the intentional flotation by means of an oil and a gas early in 1903.

Q. 7. After learning of the Froment process, did you try that process?

A. Yes, I tried the Froment process.

Q. 8. Will you describe your trial of that process, your mode of procedure and results?

A. A sample of crushed ore was taken and mixed with a small amount of powdered carbonate of lime, to this was added water, and on the top of the charge a thin layer of oil was placed. The vessel in which the mixture was, was then agitated so as to thoroughly mix the oil with the crushed ore. After the mixing was judged to be complete a quantity of mineral acid was added to the charge and

1684 the whole contents of the vessel gently stirred, the effect being that the bubbles of carbonic acid gas generated by the mineral acid on the carbonate attached themselves to the oiled particles of mineral, which, more or less completely rose to the surface of the liquor, leaving the depleted residue at the bottom of the bottle or containing vessel.

Q. 9. In the patent in suit, No. 835,120, in an example of the application of the process the amount of oleic acid used in that instance is specified as from .02 to .5 per cent. on the weight of ore, the latter quantity being twenty-five times the former. How would an operator practicing the process determine between these wide limits what quantity of oil to use?

A. As a matter of fact, both quantities mentioned are so minute in relation to the proportion of ore that it is hardly right to describe the limits as very wide, but the operator would have no difficulty in determining, if there was any marked difference, which was the best quantity to use, by simply noting whether he was obtaining the

specific frothing phenomenon which the patent indicates as being that required.

Q. 10. In other words, the ordinary skill of the operator would lead him to the right amount, as I understand it?

A. Yes, I think an operator after studying this specification, and possessing average technical knowledge would have no difficulty in so adjusting the amount as to obtain this specific and very definite form of froth.

1685 Q. 11. Did you ever try the Froment process proceeding, as directed by Froment in his British patent 12,778, of 1902?

A. Yes, certainly. The only information we had at first was from reading Froment's patent, and our tests were consequently based upon the information contained in the document.

Q. 12. I invite your attention to the passage extending from line 33, beginning with the words, "such for example," to the end of the paragraph, which begins with those words on page 2, and ask whether you ever tried Froment as there directed?

A. I have no doubt that as our experiments were conducted from our reading the specification, that a test of this kind, if not exactly of these quantities, was made. I cannot definitely remember whether exactly these quantities were used in any specific test.

Q. 13. Do you remember the result secured when operating according to Froment's patent referred to?

A. I remember generally that fairly good recoveries of the sulphide minerals were obtained, but I have no figures of any particular test, showing actual recoveries.

Q. 14. When you say that the recoveries were fairly good, do you mean that they were as good as when you operated as stated in your answer to question 8?

A. Yes.

Q. 15. When these trials of the Froment process, referred to in your answer to question 8, were carried out according to Froment's directions in the patent referred to, did you work with Mr. Sulman?

1686 A. Yes, we were working constantly together on these matters.

Q. 16. When did you first see operated or demonstrated the process which patent 835,120 in suit purports to describe?

A. About the first week in March, 1905.

Q. 17. Have you any means of fixing this date other than by your been under investigation for quite a lon gperiod, had they not?

A. There were certain reports issued by the works where the process was operating, and certain correspondence and reports issued from our office relating to the discovery, and these aid me in fixing the date approximately. I do not think I am more than a fortnight wrong in my date. If so, it would be earlier rather than later.

Q. 18. Who conducted this first demonstration which you saw?

A. One of the works staff of Minerals Separation, named Mr. Howard Higgins. Mr. Higgins was at that time engaged under instructions from Mr. Sulman, Mr. Ballot and myself, in investigating, amongst other things, the influence of the quantity of oil on

Cattermole granulation, and it was as a result of repeatedly reducing the quantity of oil that eventually we arrived at the production of the specific, permanent and coherent froth which is referred to in the patent in suit.

Q. 19. These various factors affecting the Cattermole process had been under investigation for quite a long period, had they not?

1687 A. Investigation was always going on, but this particular investigation was originated by Mr. Sulman, Mr. Ballot and myself, not very long prior to the time that this discovery was made. We did issue a report which gives the list of investigations to be made and the date of that report will indicate how long the investigations were proceeding before we made this actual discovery.

Q. 20. Were you present when what you call the discovery was made?

A. I was not in the works at the actual moment when the first froth was produced, but I certainly saw it within an hour or two of its production. I believe Mr. Ballot, one of the patentees, was present at the moment of its production, and it was Mr. Ballot who, after seeing it, sent for me and Mr. Sulman to inspect it.

Q. 21. Where were you and Mr. Ballot and Mr. Sulman when you gave these instructions to Mr. Higgins regarding the subjects to be investigated regarding the Cattermole process?

A. We three were meeting every day for discussions on these matters, and I think the specific instructions referred to were come to at a meeting of us three at our office, 44 London Wall, but I cannot be quite certain that they were not arrived at at a meeting at Mr. Ballot's office. I clearly, however, remember the meeting and the discussion which led to adopting the programme of work to be done.

Q. 22. And about how long do you think this was before

1688 you were told that the discovery referred to was made?

A. The discovery was made in March, 1905, and if I might see the report which we wrote on the subject I think I could fix the date of the instructions. I now see that in the report dated March 3, 1905, there is a record of the instructions which were being carried out at the time, but it does not fix the time of meeting at which they were determined upon. I thought that some of these reports might have more specifically fixed the time, but apparently they do not. I am not, therefore, able to say how long the experiments had been going on.

Q. 23. Were these instructions given to Mr. Higgins as much as a month or two before the discovery was made?

A. My memory will not serve me, I could not say.

Q. 24. Can you fix the date by memory within a year?

A. Yes, it was certainly a matter of weeks before, and within that year, at least that is my impression.

Q. 25. Now, as a matter of fact, Mr. Higgins had been investigating these various factors, including the amount of oil, acid, agitation, temperature, and so forth, for probably two or three years prior to the period of 1905, had he not?

A. I do not know how long Mr. Higgins had been at work, and I

cannot fix the time he began work upon it. Of course inves-
1689 tigation was constantly going on during the developing stages of the Cattermole process, and Mr. Higgins, after he had been trained by us in oil work, took part in these investigations.

Q. 26. Is it your impression that at the time of this meeting between yourself, Mr. Ballot and Mr. Sulman, it was a new idea to investigate how much oil, acid, and what character of agitation should be used in the Cattermole process?

A. My general recollection is that we had been for some time working, more or less in the dark, without understanding the influence of the various factors of the process, and we decided that it would be well to adopt some form of definite line of research, with a view, if possible, of clearing up various points of difficulty in connection with the work.

Q. 27. Do you mean to convey the idea that prior to the meeting between yourself, Mr. Sulman and Mr. Ballot, to which meeting you have referred, the experimentation by the staff of Minerals Separation, including Mr. Higgins, had been more or less desultory and unsystematic, and that you decided to have them systematize their operations?

A. I certainly do not accuse the staff of Minerals Separation of carrying out their work in a desultory manner, because if I did I would be equally accusing myself, who was largely responsible for the work. In developing an entirely new process such as this, one must necessarily for a time come across factors, the meaning of which
are not clear, and in the early stages much of the work must
1690 necessarily be of the trial and error description, and to that extent I am prepared to admit a certain amount of desultoriness.

Q. 28. I notice from the documents of your firm and of Minerals Separation, Ltd., which have been shown to us during this proceeding, that the Cattermole process was not a new idea as early as March, 1903, and I see from these reports that experimentation for the purpose of perfecting this Cattermole process was active from a date at least as early as March, 1903, down to the year 1905; that during that period, and during the early part thereof, the various factors of the process were altered in the various experiments. Now, what I want to have you tell us is just what difference was brought about in this experimental work by the instructions which you say were given jointly by Mr. Ballot, Mr. Sulman and yourself to Mr. Higgins, or to other members of the staff?

A. I find that question somewhat difficult to answer. During the earlier stages we had been experimenting largely on different types of plant, on different ores, and it was only after a great deal of that work had been done that the plant appeared to have become somewhat established and systematized, and starting on that assumption it was decided to more systematically than hitherto attack the problem of the influence of these factors in our then fairly well established type of apparatus.

Q. 29. The effect of these instructions, then, as I understand it,

was not so much to change the character of the work as to
1691 make it more systematic; am I right in this?

A. I do not quite understand what you mean by the character of the work.

Q. 30. By the character of the work I mean the nature of the investigations, such as endeavoring to ascertain the most advantageous quantities of acid, oil, possibly dilution of the pulp, character of agitation, temperature and such other factors as would naturally appeal to an operator of the process as being important. With this explanation can you answer the question?

A. I think I can only answer your question by saying that the object of the investigation embodied in the instructions was to give us a better knowledge of the working of our process than we had before and thereby to give us more control over it.

Q. 31. Work for the attainment of that purpose stated as generally as you state it, had been going, had it not, for over two years prior to the instructions given by yourself, Mr. Sulman and Mr. Ballot?

A. I thought I had dealt with that in a previous answer. True, work of an investigating character had always been going on, but in the early stages we were a much longer way off finality, so far as conducting the operations were concerned, as we had settled on the final type of plant, and probably also on the best oils to use. It was only after much of this, what I have described, as trial and error work was done, that one could hope to systematize the work in a more definite manner than had been possible hitherto.

1692 Q. 32. And the effect of the instructions to Mr. Higgins was to systematize the work in the more definite manner that you have referred to, was it not?

A. I presume so; that was the object, anyhow.

Q. 33. In what kind of an apparatus was the process of the patent in suit No. 835,120 performed, when you first saw it performed?

A. It was performed in an ordinary gabbet or cone mixing vessel, fitted with usual baffles, such as was employed for the usual Cattermole process.

Q. 34. When you first saw the process it was not so arranged as to operate continuously, I presume?

A. No.

Q. 35. It is desirable, I presume, to perform such a process continuously, is it not?

A. Yes, certainly.

Q. 36. As a commercial proposition, I presume the process would hardly be capable of use unless provided with apparatus for operating it continuously, at least such would be the case unless a very valuable ore were being operated upon?

A. It is, of course, always desirable to make any metallurgical process continuous, if possible, though intermittent processes may be quite commercial in their results, but this process lends itself very readily to continuity.

Q. 37. What was next done in providing an apparatus for this process after its demonstration in the apparatus you have referred to?

A. I think the next step was building and fitting a spitz-
1693 kasten arrangement to receive the agitated material whereby the separation of the froth should take place with deposition of the gangue.

Q. 38. What was the location of the laboratory or shop where you first saw the process operated?

A. Aldermanbury avenue, E. C.

Q. 39. Will you state, as nearly as you can remember, how many different apparatuses, whether large or small, were constructed at the laboratory on Aldermanbury avenue for the application of this process, describing such machines briefly as you go on?

A. I know that in all several plants of various sizes were built, but I am quite unable now to recall the different plants and locate them correctly at the different works occupied by Minerals Separation during their work. I may say, that in 1906, in the early summer, I think, I went abroad, not in connection with this business, and from this time I had very little to do with the practical development of the process.

Q. 40. Were you in touch with the work upon this process up until your departure abroad?

A. Yes, I was.

Q. 41. Then, will you describe, as nearly as you can, the construction and operation of the first machine built and operated after the first demonstration of the process shown to you?

A. I have not much detailed recollection of the plant or plants employed, I only remember generally that gabbet or cone mixers were used, which were in series, which were connected to-
1694 gether, and that the last of the series discharged through a turned-up pipe and delivered the material onto a short launder, whence it was conveyed to a series of spitz boxes.

Q. 42. These spitz boxes were provided with upward water currents, were they not?

A. I believe they were, in the first instance, but if my memory serves me rightly, their use was soon abandoned, but I cannot speak with certainty on this point.

Q. 43. Do you remember whether you obtained satisfactory concentrates?

A. Yes, we did.

Q. 44. In what form were these concentrates obtained?

A. They were floated off as a thick, coherent, persistent froth, off the end of the last spitz box of the series, where they were collected in some collecting vessel.

Q. 45. Were any of the concentrates obtained in any form, other than the thick coherent froth you refer to?

A. No, not when the plant was working normally and properly.

Q. 46. When the plant was not operating normally and perfectly what happened?

A. You mean specifically with regard to the nature of the concentrates?

Q. 47. Yes.

A. Well, for example, if through any accident the ore feed failed

and the oil feed continued, an excess of oil would be supplied
1695 and some of the mineral would form rather as granules and sink, or occasionally through any blocking of the delivery pipe a little concentrate might escape, or such concentrates as had already just been delivered might be pulled out rather in the form of a film on the spitz box than as froth, but these incidents were quite abnormal, and generally speaking, I am right in saying that the thick coherent froth always resulted.

Q. 48. During the period from 1903 to 1906, when you were in touch with this work, I understand that quite a number of different apparatuses, large and small, relatively, were constructed for the purpose of carrying out this process. What was the purpose of building this succession of different apparatuses?

A. To arrive at that most suitable to carry out the desired object.

Q. 49. Is it your recollection that the later machines were more suitable for that purpose than those first formed, that is, first formed with spitz boxes?

A. Yes, later ones were certainly better in various detail particulars than earlier ones.

Q. 50. In what particulars did the later machines differ from the earlier ones?

A. One difference lay in the adoption of wooden mixing vessels, which was advantageous on the ground of economy. Other alterations consisted in the mechanical details of driving the shafts of the mixing vessels, which in the earlier machines were frequently badly damaged, and another alteration adopted in the latest types
1696 was replacing the cone gabbet agitator by a blade form of agitator. I have no doubt that other detail developments took place, but those are the ones which strike me most. I remember also that there was a different arrangement of the spitzkasten part of the plant. I have recollection of one plant in which two or three spitz boxes were placed underneath each other instead of all being in one tier, and another alteration that I remember was placing the spitzkasten close up to the delivery of the last mixer instead of conducting the pulp through a short launder. That, I think, generally indicates the changes that were made in the various plants.

Q. 51. In the early apparatuses in which the last mixing box delivered the pulp upon a launder or tray, through which, or over which, it flowed, to the spitz box, what was the purpose or function of such a launder or tray as used?

A. I do not recall that it had any particular function, and it was possibly only put in for some structural convenience to connect the two parts of the plant. I am not aware of any appreciable difference in the results, whether such a tray is used or not. The plant is certainly a little more compact without it, and probably that accounts for its disappearance.

Q. 52. During this period of development you are aware of no reason for introducing any change in the first apparatus which you saw, other than the simple desire to make the apparatus more compact, or to simply adapt it to the shape of the space where it was to be placed, or something of that kind?

1697 A. I cannot recall any particular reason except for improvements in mechanical details. I may say that the process, in my opinion, worked perfectly in the first plant, and therefore, except for mechanical reasons, I can recall nothing which might be held to be an essential alteration in the working of the process.

Q. 53. Do you know whether any plant was ever introduced into actual use, following the design of this first spitz box machine, and whether it was successful?

A. I know that the process was introduced into Australia, but how far the design of the plant in use differs from the early ones, I have no knowledge.

Q. 54. You cannot, then, speak from your own knowledge as to the precise order of steps or proportions of different materials that were used in the process which you have referred to in Australia?

A. No, I have no personal knowledge.

Q. 55. You have never met, nor had any communication, by correspondence or otherwise, with Mr. James M. Hyde, defendant in this case, before today, have you?

A. No, I have not.

Q. 56. Do you remember whether any of the experimentation with the various apparatuses built, after the first spitz box machine, was directed towards obtaining results of the character which you had been informed had been secured in Australia?

A. I believe so, but I have very little knowledge of what took place after the plant was working in Australia. I was engaged at this period mainly on another business.

1698 Q. 57. Do you remember in what respect it was desired by Minerals Separation, Limited, to duplicate the operation carried on in Australia?

A. My general impression is rather that Australia got its instructions from London than that Australia supplied information to London. Of course, there was a constant interchange of developments on both sides.

Q. 58. You remember, do you not, that there was an effort in the construction and operation of the various machines in London to profit from some of the suggestions received from Australia or to secure results that you were informed had been secured there?

A. No doubt some information of value was obtained from Australia, particularly as to the questions of horse-power required, wear and tear of plant, and on such points as would naturally be best determined on a large scale working plant.

Q. 59. During the period up to 1906, when you went abroad, do you remember of ever having had your efforts directed towards securing as good operation of your experimental machine in London as was being secured by the apparatus in use in Australia?

A. No, I have no recollection on that point.

Q. 60. Have you any personal knowledge as to whether the process of patent 835,120 was in practical use in Australia at all prior to your leaving for abroad?

A. I do not know when the process started to work in Australia.

Adjourned to Saturday, August 10th, 1912, at 10:30 A. M., at the same place.

1699 London, August 10th, 1912.

Met pursuant to adjournment.
Present: Counsel as before.

Direct examination of Hugh Fitzalis Kirkpatrick-Picard continued:

Q. 61. I presume the words froth and scum are used synonymously in the patent in suit; are they not?

By Mr. Williams: Objected to as calling for a construction of the language of the patent, and therefore incompetent.

A. Yes, they are.

Q. 62. I presume in this experimental work which you and Mr. Sulman were engaged in in connection with Minerals Separation, Limited, and the gentlemen connected therewith, you frequently found the flotation effect and the granulation and precipitation of mineral to appear simultaneously?

A. In your question do you refer to our work on the froth flotation process or to our work on the Cattermole granulation process?

Q. 63. You may limit your answer to your work on the Cattermole granulation process.

A. Yes. In working the Cattermole granulation process we certainly found that some of the mineral in the form of granules tended to float though the great bulk of the mineral was recovered in the form of sunk granules. The small amount of floating mineral obtained in this process was a source of trouble to us.

1700 Q. 64. In operating the process, which the patent in suit purports to describe, was it your invariable custom to establish a quantitative relation between the amount of oil and the amount of ore, or did you sometimes proceed simply by using such a quantity of oil as would produce the result you desired, without knowing just the quantitative relation of that amount?

A. In all our tests we endeavored to maintain an approximately definite relationship as to quantity between the amount of ore and the amount of fuel fed into the plant.

Q. 65. Did you have anything to do with the practical operation of the process of 835,120, that is, with its introduction into actual business use?

A. I had nothing to do with the operation of the plant in Australia, and have never seen it there. I took part in discussions relating to the type of plant which was to be used in Australia, but that is my only connection with it.

Q. 66. Have you any personal knowledge as to whether the procedure set forth in the patent in suit and the apparatus there illus-

trated, ever proved satisfactory and successful in actual concentration in a commercial way as distinguished from laboratory experiments?

A. I have never seen the operation at work on a large scale on a mine anywhere.

Q. 67. Will you state the distinction between the froth or scum which is referred to in the patent in suit, and the floating ma-
1701 terial resulting from operations such as described in United States patent 793,808, granted to yourself and Mr. Sulman on July 4th, 1905, as the result of an application filed October 5, 1903?

A. I have already described the froth produced in the patent in suit as being of a very dense, coherent and thick deposit. The floating concentrate obtained in patent 793,808, on the other hand, was of a very feeble and tender character, the very reverse of coherent and persistent, and was of such a nature that extreme care had to be used in its collection. It never reached any appreciable thickness, and was rather of the nature of a thin film.

Q. 68. To what do you attribute the difference between the condition of the floating material produced in accordance with the process of the patent 793,808 and that produced under the process which patent 835,120 purports to disclose?

A. I attribute the difference largely to the greater quantity of oil that was used in working the patent 793,808. The oiled mineral produced under this patent was more of the Cattermole variety, and in our experience air introduced in the manner shown in Figure 1 does not attach itself very readily to these particles of mineral heavily oiled, and though the air did, to a large extent, carry the mineral flocks to the surface, they, the flocks, seemed to sink again with ease in such a manner as to suggest that the air which caused them to float had freed itself from the particles.

Q. 69. Was an apparatus such as shown in Figure 1 of patent 793,808 built and operated?

1702 A. Yes, something very similar to this. I do not recall an apparatus similar to Figure 2, but I have a definite recollection of something of the nature of Figure 3 having been tried.

Q. 70. I take it, then, that you attribute the defective action which you have referred to in the operation of the apparatus of Figure 1 of 793,808, to the use of too much oil?

A. Yes, I think that in large measure accounted for the relative non-success of this process, but on the other hand, I do not think success would have been obtained with this particular apparatus, even though the quantity of oil had been much reduced.

Q. 71. From which I infer that it is your idea that the success of a froth flotation process of this kind is dependent, not only upon the use of the proper quantity of oil, but also upon the use of mechanism adapted to bring about other conditions equally necessary to the production of a froth?

A. Of course suitable apparatus must be employed to carry out the object set forth in the patent specification, and we show one method by which these objects may be obtained, but no doubt other forms of appliance would effectively carry out the intention of the patent which is essentially the production of the dense persistent

and coherent froth which is the peculiar attribute and essential feature of this invention.

Q. 72. You refer to this froth as dense, coherent and thick; is the process of patent 835,120 limited to a froth which is dense,
1703 coherent and thick, as distinguished from some other kind of a froth which you have had experience of?

By Mr. Williams: Objected to as calling for a construction of the scope of the invention covered by the patent in suit, and therefore incompetent.

By Mr. Scott: Question withdrawn.

Q. 73. You have referred to the froth produced by the process which the patent in suit purports to set forth as dense, coherent and thick. Does that process in practice result in producing a froth which is distinguished from other froths which you have seen produced in these characteristics of density, coherency and thickness?

A. According to my experience, the characteristics of this froth are essentially different from any other kind of mineral froth that I have seen produced.

Q. 74. Are these characteristics so essentially different that observation of a froth enables you to state whether it has been produced by the process which patent 835,120 purports to set forth, or by some other process?

A. I do not think I should have any difficulty in distinguishing between the froth obtained by the patent in suit and that produced by any other means known to me.

Q. 75. Could you distinguish, by observation, that is, by visual observation, between froths produced by the use of five-tenths
1704 of one per cent., one per cent., one and a half per cent. and two per cent, respectively, of oil?

A. I should have no difficulty, I think, in distinguishing the five-tenths per cent. froth from the two per cent. and probably from the one and a half per cent., but I do not know what is the absolute limit in quantity which would render it difficult for me to distinguish between them. I may state that by using the upper limit of two per cent. in the apparatus described in the patent in suit I should expect to find an appreciable quantity of granules formed, and this would aid me in forming an opinion as to the amount of oil used.

Q. 76. Do you remember about when Mr. A. Howard Higgins entered the employ of Minerals Separation, Limited?

A. My recollection of it was that in December, 1903, he entered our employ, and that in June, 1904, he joined the Minerals Separation staff.

Q. 77. In carrying out the process which the patent in suit purports to disclose, is there anything distinctive about the mode of agitation of the oiled pulp as compared with the agitation used in applying the Cattermole process, wherein the purpose is to granulate and precipitate the valuable mineral?

A. In actual fact the same apparatus was employed for both pur-

poses during my connection with the experimental work on the two processes. In the patent in suit it is more essential to beat in air, which is not an important point, and rather to be avoided,
1705 in the Cattermole process, where the object was only to mix the various ingredients, air not being one of them.

Q. 78. In operating the apparatus of the patent in suit as shown in Figure 1 of the drawings, does the material come out of the pipe H in the form of a froth, or did the froth form upon the apron or tray O, or did it rise from the body of the liquid in the spitz boxes, or did it collect in some other way which does not occur to me?

A. I should say that the froth was present, so to speak, potentially in the pipe H, that is to say, if the gabbet agitator had been stopped, froth would at once have risen to the surface of the liquid in the gabbet; the charge, therefore, in passing through the pipe H was in condition to form froth at the earliest moment that it had an opportunity to do so. My impression is that the actual froth did not form until the pulp reached the spitz box, but it is quite possible that some froth began to form on the tray O.

Q. 79. You have referred to having been called in to witness the operation of forming a froth according to the process which the patent in suit purports to set forth shortly after the discovery of such a mode of procedure was made. Will you state just what you saw on this occasion that was new to you; that is, what was it you regarded as a discovery?

A. What struck me as being new was seeing practically the whole of the mineral which was in the ore charge floating on the top of the liquid in the gabbet whilst at rest, whereas hitherto when
1706 using larger quantities of oil I should expect, and, indeed, would have seen the mineral in a more or less granulated condition through the charge, and not floating on the surface, except as to certain accidental flocks. The difference was most marked, and created a very distinct and decided impression on my mind.

Q. 80. I presume that you and your associates proceeded to investigate the causes which had produced this result, and if so, what were the causes to which you attributed it?

A. We already knew from the first test that the cause was due to reducing the quantity of oil much below that hitherto employed, and observation of the froth clearly indicated that the air which had been beaten in played an important and essential part in the production of this new phenomenon. I presume that further investigation work was carried on, but in my opinion, the invention may be said to have been complete after that first operation.

Q. 81. At the time the process which the patent in suit purports to set forth was first exhibited to you, I take it that you were not then for the first time made cognizant of the possibility of using so small a quantity of oil as had been used, or that you then first became cognizant of the utility of beating air into the pulp; am I right in this?

A. I had no idea prior to this, that by reducing the quantity of oil to the limits which were used in this experiment that such a result would be obtained. I, of course, knew that air would

1707 float mineral, previously oiled, but it was not anticipated by me hitherto that this particular result would be obtained if air were beaten in, in the manner in which it was done in making this test. The result of the operation as a whole was an entire revelation to me, and though I knew that work was being carried out on the reduction of the quantity of oil, I never for one moment anticipated in my mind, as being likely to occur, what in fact actually did occur.

Direct examination closed.

Cross-examination.

By Mr. Williams:

X Q. 82. In Q. 11, you were asked if you ever tried the Froment process as directed by Froment in his British patent 12,778, of 1902, and in Q. 12 your attention was called to a particular passage in the Froment specification, commencing on line 33 of page 2, and you were asked whether you ever tried the Froment process as there directed. Please explain fully your answers to those two questions, supplementing what you have already said by anything further which may be necessary to make your meaning clear.

A. Perhaps the only point that wants elaborating is the order in which I added the various ingredients. I made a large number of tests, and it is possible that in some of them the order may have varied from that which I gave in answer to question 8. What I did was to take the specification and exercise my knowledge of these matters to the best advantage, so as to obtain the best result that the process was capable of. It was therefore my usual practice
1708 to add the acid after the other ingredients as I wished to get the oil well mixed with the ore before destroying the carbonate of lime present, which was necessary to produce carbonic acid gas for the separation of the oiled mineral. That I was right in this procedure is clear, because at a subsequent date Messrs. Minerals Separation received instructions from Froment on how to work his process, and in these instructions he advised the performance of the operation on exactly the lines followed in my experiments. This is clear, not only from written instructions, but also from a drawing which was supplied, in which the mixing without acid is shown in one vessel, and the separation by the addition of acid in a second vessel.

By Mr. Scott: All of the answer beginning with the words "that I was right," and extending to the end of the answer, is objected to as hearsay.

X Q. 83. Can you, and will you, produce, Froment's description to which you have referred, and also his drawings, to which you have referred?

A. This is the description, and these are the drawings.

The Commissioner notes that the witness produces a document in French, entitled "Description et Instructions pour la concentration des minerais," and a large and small sheet of drawings, and at the request of counsel for complainants, marks the description for identification as "Froment Description," *and* the large drawing as
1709 "Froment Drawing D," and the small drawing as Froment Drawing A."

X Q. 84. In addition to the description and drawings was, or was not, any apparatus received from Froment?

A. Yes, he sent over a small-sized plant to be used in carrying out his process, but I never used this apparatus, because, firstly, I did not conider it by any means a satisfactory appliance to effect the operation, and I was satisfied that only indifferent results could be obtained upon its use. Further, the apparatus was of too large a size for use in our laboratory. It was sent eventually to Minerals Separation Company's works, but I have no knowledge of whether they used it or not. A search for this apparatus has been made, but I expect it has been destroyed. Certainly it has not been found.

Cross-examination closed.

Redirect examination.

By Mr. Scott:

R. D. Q. 85. Do you remember whether you carried out the process of the Froment patent before you received the instructions and drawings from Mr. Froment, to which you have referred?

A. Yes, certainly, many tests were made before we received the drawings and instructions.

Redirect examination closed.

Deposition closed.

HUGH F. K. PICARD.

Adjourned to Monday, August 12th, 1912, at 2 o'clock, at the same place.

1710 London, August 12th, 1912.

Met pursuant to adjournment.
Present: Counsel as before.

JOHN BALLOT, a witness produced on behalf of defendant, having been duly cautioned and sworn, testifies as follows:

Direct examination.

By Mr. Scott:

Q. 1. What is your name, age, residence and occupation?

A. John Ballot; age, 52; residence, at Hotel Cecil, Strand, London; my occupation is chairman and managing director of Minerals

Separation, Limited, and chairman of Minerals Separation American Syndicate, Limited, the two complainants; place of business, 62 London Wall, London, E. C.

Q. 2. Was Mr. Hyde, the defendant, employed directly by Minerals Separation, Limited, or by a syndicate of which Minerals Separation, Limited, was a member?

A. Mr. Hyde was employed by Minerals Separation to carry out the work of the syndicate formed to investigate in Mexico. He was paid directly out of the funds of the syndicate.

Q. 3. Who were the members of the syndicate?

A. The members were Messrs. Lazard Brothers & Co., London; Messrs. Beer, Sondheimer & Co., of Frankfurt, and Minerals Separation, Limited, London.

1711 Q. 4. Did all three of the members of the syndicate contribute towards the funds of the syndicate?

A. Yes.

Q. 5. You mean that each member of the syndicate, including Minerals Separation, Limited, contributed money to the treasury of the syndicate?

A. I do.

Q. 6. It is averred in the bill of complaint in this suit that the defendant was instructed by the engineers and experts of one of the complainants or both of them in all technical details and particulars as to the letters patent in suit, and the installation and use of the process of ore concentration constituting the invention set forth in said patent. Can you state any particular or specific instructions which were so given to the defendant, Mr. Hyde?

A. Immediately after Mr. Hyde's arrival in London, Mr. T. J. Hoover, who was then our consulting engineer, which practically means that he was the chief engineer of the company, was requested by me to give Mr. Hyde every possible instruction and all information necessary to enable him to acquire the necessary knowledge to equip him for the purpose of the duties which he was destined to undertake and had undertaken to carry out in the Republic of Mexico. I may here mention that I understood from both Mr. Hoover and Mr. Hyde that they had known one another for years, and Mr. Hoover assured me that Mr. Hyde was a fully qualified engineer, to whom the business could be safely entrusted.

1712 Mr. Hoover, on my instructions, placed at Mr. Hyde's disposal, all the files of patents in our office relating to the Minerals Separation processes, not only the patent in suit, but everything on file at the time. Mr. Hoover also placed at Mr. Hyde's disposal his own reports and notes on the process made during his visit to Australia, as well as comments and notes relating to the patents and processes. After spending some days or probably weeks, I do not know how long, in mastering these details, he was taken to our test works, then at Charlotte street, off Great Eastern street, where he was shown various apparatus, both small scale and large testing plant in use and operation at that time. I personally had discussion with Mr. Hyde before he left for Mexico and asked him whether he had gained all the information that he thought necessary

to enable him to carry out the work which he had undertaken, and he gave me his assurance to the effect that he had. I would here mention that before Mr. Hyde arrived in London a special type of machine had been invented or designed by Messrs. Sulman & Picard, known as the slide machine. Messrs. Sulman & Picard communicated the information to Mr. Hoover, Mr. Hoover discussed it with me, and at my request took the matter up to have similar machines built for use in our Charlotte street works. The details of this invention were communicated to Mr. Hyde by Mr. Hoover, and our works manager, Mr. A. C. Howard, together with Mr. Hyde, were entrusted with the building of this by suitable makers. So soon as this machine was built one was placed at the disposal of Mr. Hyde, and he was given one of our works operators or experi-
1713 menters, together to run through a series of tests as quickly as possible to get the handling of the machine and generally to become efficient in the management of it, as it was found to be a very efficient apparatus that would just suit the operations of the testing work with which Mr. Hyde was to be entrusted during his Mexican and other investigations for the purpose of acquiring business for the syndicate. With this machine and with another one subsequently sent to him, Mr. Hyde carried out his tests, not only in Mexico, but also in Canada, where he was requested to go, and did go, early in November of 1910.

By Mr. Scott: That part of the preceding answer which sets forth alleged disclosures made by Mr. Hoover to the witness is objected to as hearsay.

Q. 7. What is the source of your information to the effect that Mr. Hoover placed at Mr. Hyde's disposal all the files of patents in your office?

A. First, I requested him to do so; secondly, he assured me that he had done so; thirdly, because I saw Mr. Hyde reading them myself.

Q. 8. Does the preceding answer as to your source of information apply also to Mr. Hoover's reports and notes on the process made during Mr. Hoover's visit to Australia, and his notes relating to the patents and processes?

1714 A. My recollection is yes, with this qualification that when I make use of the word "process" I refer to the patent in suit, which was being applied and worked on a commercial scale, and which, of course, we wished Mr. Hyde to introduce into Mexico.

Q. 9. What was the nature of these reports and notes made by Mr. Hoover during his visit to Australia and his notes relating to the patents and processes?

A. To give a clear answer I should require to refresh my memory by reference to the documents. In general, the notes on his visit to Australia were on the working of the apparatus and the process there in practice. With regard to the patents and processes he had drawn up a memo. of their sequence and their various characteristics.

Q. 10. What did Mr. Hoover go to Australia for?

A. Mr. Hoover at that time occupied the position of general manager of Minerals Separation, and the Board thought it advisable to send him to Australia for the purpose of seeing the process worked on a large scale, and also to investigate the operation of a large scale plant previously erected, that is to say, erected previous to Mr. Hoover's joining our company, and operating or treating a dump of tailings purchased by my company, jointly with others, from the Sulphide Corporation, and to report thereon.

Q. 11. I presume you yourself have been in Australia and seen the working of the process in question there?

1715 A. I have not.

Q. 12. Had any of the members of the Board to which you refer seen the process, to which you refer, in Australia?

A. Yes, only one, Mr. J. H. Curle.

Q. 13. At the period in question, namely, at the time of Mr. Hoover's visit to Australia, was the process being operated commercially anywhere except in Australia, by commercially I mean as distinguished from the testing operations, which I understand were conducted in England or Wales?

A. No, with the exception of the London and Welsh works, it was not operated anywhere, to my knowledge, on a commercial scale. My meaning is, it was worked in Australia.

Q. 14. The operations at London and in Wales were not of a commercial character, were they, that is, were not being conducted in the regular course of mining operations?

A. The London works were purely testing and investigation works. The plant in Wales was erected for the special purpose of producing concentrates from a shipment of several hundred tons of San Francisco Del Oro ore, which that company had sent to England to test out a process of zinc smelting, and this Welsh plant was erected at the works of a small smelter company in Wales with that object, and it produced a tonnage of concentrates from the San Francisco ore for their smelting tests.

Q. 15. What was your purpose in directing Mr. Hoover to

1716 instruct Mr. Hyde as to the practice of this process, and to put in his hands his notes regarding the Australian practice?

A. To give Mr. Hyde as much information as possible of work on a practical scale, as no work on a commercial scale was being done in England, with the exception of the tests in Wales, and that plant also Mr. Hyde was specially requested to visit to gain as much information as he could.

Q. 16. I take it from what you have said, that you yourself have no personal knowledge as to how the process in question was carried out in Australia, and that you cannot from your personal knowledge describe that process or the mechanism used for the purpose of putting it into effect; am I right in this?

A. If by personal knowledge you mean personal inspection, you are right. On the other hand, I have naturally had the reports of our engineers and members of the staff who erected the plant and operated it.

Q. 17. Did you yourself direct these engineers to proceed to Australia for the purpose of introducing the process?

A. In the first instance we sent out Mr. Chapman, who had received his instructions, drawn up in consultation with Sulman, Picard and myself.

Q. 18. At what date, as near as you can remember, did you first send any one to Australia for the purpose of introducing the process which the patent in suit purports to describe?

A. We sent out Mr. Chapman, as far as I can remember,
1717 early in 1904, probably March, I am not quite sure, with the Cattermole plant. He erected that, operated it, and during the early part of 1905, a hundred-ton plant of the Cattermole type was built at the Sulphide Corporation works, and, I think, was completed and started operation about May, of 1905. That plant operated for a short period, but in the meantime the oleic acid froth or agitation froth process was discovered and information of same sent out to Mr. C. F. Courtney, who was our consulting engineer in Australia at the time. And if my memory serves me rightly, early in July he tested the frothing process in this particular Cattermole plant, and soon after converted the Cattermole plant into a frothing process plant. I find on looking at my letter-press copy book that I wrote Mr. Courtney on the 3rd of March, 1905. I quote from this letter as follows:

"And also to hand you copies of Messrs. Sulman & Picard's report of the 3rd inst. together with Mr. Higgins' of 2nd inst., with two sheets of curves to show the very important results obtained. As the various reports and curves will explain themselves I have but little to add, and I trust that you will be pleased with the result."

Again in my letter to Mr. Courtney of March 10th, 1905, I say:

"I am pleased to tell you that during the week we have made some very important discoveries which will, I think, almost revolutionize
1718 our processes by way of simplifying and cheapening the same. I hope that by next mail the work will be sufficiently far advanced to send you full particulars. Several points have yet to be determined, and the discoveries are of such a nature that we have decided to take our expert and Counsel's opinion thereon with a view to assuring ourselves that we can get good protection under patents. I may mention for your private information that we do not use more than .1 per cent. of oleic acid per ton of ore and although we have not assays out that the recoveries will be very satisfactory."

Again in my letter to Mr. Courtney of March 17th, 1905, I say:

"Higgins Report. Herewith I enclose you copy of Higgins report as received this morning, being a continuation of the one sent you on the 3rd March. By using one per cent of acid water or even less than that, three of water to one of ore, and adding .1 per cent of oleic acid, and heating the circuit to from 30/32 C and then agitating from 8 to ten minutes in a single gabbet we find that almost as soon

as the cone is stopped in the gabbet from 70 to 80 per cent. of the contained mineral immediately rises to the surface in the form of scum or froth which floats persistently and remains on the surface of the water for days at a time. Any heavy mineral that may be present and not carried up with the froth is readily separated
1719 from the coarse sands by ordinary tabling. This experiment has been repeated again and again. The ore treated was ground to 60 mesh originally but we found that only a very small percentage remained even on 90 mesh the bulk passing through one hundred and fifty. I think this discovery very important indeed, and have no doubt that you will thoroughly test it on your straight ores as well as on your tailings and old slimes, especially the stack of rich slimes on the mine as it will merely need agitation and running off into settling tanks with some mechanical device for skimming off the floated froth or perhaps a large nest of conical upcasts or spitzkasten may be made to do the work and I have no doubt that you will soon solve the mechanical problem for fixing up suitable apparatus.

"As I wrote you in my last, we are having our patents thoroughly overhauled in view of these developments, and it will therefore be necessary to keep this as confidential as possible until we know the result. Even with thirty mesh stock Higgins finds that although not much flotation takes place as only the slime mineral rises to the surface, the coarse mineral is still sufficiently oiled to permit a perfect separation by tabling with air-blast by air-distributor. This factor is important as it reduces the consumption of oleic acid to a vanishing point being only .1 per cent per ton of ore treated and that can be very readily washed off the concentrates with a
1720 weak alkaline solution for the purpose of separation or breaking-down. In the case of copper ore or ores not requiring separation, I take it that it will hardly pay to recover the oleic acid."

The Commissioner at the request of counsel for complainants marks for identification the letter-press copies of the three letters referred to by the witness, respectively, as "Courtney Letter," followed by the date of the letter.

By Mr. Scott: The statement contained in the second sentence of the last preceding answer regarding the erection in Australia of the Cattermole plant is objected to as hearsay, as is also the statement in the following sentence regarding the operation of that plant. Similar objection is made to the statement contained in the fourth sentence to the effect that the Cattermole plant was converted into a frothing process plant.

Q. 19. What was the purpose of having your patents thoroughly overhauled, as set forth in your letter of March 17, 1905?

A. I think just a business precaution.

Q. 20. Why is it that you cautioned Mr. Courtney to keep the information contained in your letter of March 17th, 1905, confidential until you knew the result of the overhauling of your patents?

A. So far as my memory serves me the object of doing so was because at that time Australia was not under the Patent Con-
1721 vention, and if any information had leaked out before we had lodged a patent there somebody else might have pirated the idea.

Q. 21. What did this have to do with the overhauling of the patents which you already had?

A. It is an expensive matter to take out patents, and we did not wish to take out patents needlessly if the discovery had already been protected by any of our previous patents.

Q. 22. Who were the members of the Board to whom you refer in your answer to question 10?

A. The members of the Board were Dr. Gregory, Mr. J. H. Curle, Mr. W. W. Webster, Mr. Francis L. Gibbs, myself, and Mr. A. H. Krohn.

Q. 23. How long had these gentlemen been associated with you in the investigation or exploitation of processes of the kind we are discussing?

A. They were all of them associated with me from the registration of Minerals Separation, which I think took place on the 31st December, 1903, except Mr. Francis Gibbs, who joined the Board probably a year later, but I am not certain. Previous to 1903, Mr. Webster, Dr. Gregory and Mr. Curle were associated with me in the Cattermole Syndicate. I think that was registered in September, 1903, but they were also interested in the investigation of the Cattermole process, which was taken up early in 1903. That is, an option was taken up over the Cattermole process and we found the money to investigate that, with an option to acquire it in syndicate form.

Q. 24. Were these other gentlemen whom you have men-
1722 tioned actively engaged with you in these enterprises, or did they leave the conduct of affairs entirely to you?

A. I think I may answer without egotism that the conduct of affairs was entirely left to me.

Q. 25. Did these gentlemen confer with you at all regarding the enterprises you have referred to?

A. We had regular Board meetings and met almost daily and discussed matters, except that Mr. Curle was a great traveler and was frequently abroad.

Q. 26. Were these discussions confined to the financial aspect of the enterprises, or did these other gentlemen enter into questions regarding the practical operations in the various laboratories which I understand Minerals Separation and the Cattermole syndicate conducted?

A. We discussed practically everything that concerned or related to the company, although the technical part was almost entirely left to my decision.

Q. 27. Did you consult these other gentlemen regarding the technical matters?

A. Not necessarily consulted them, I discussed it with them, and

it was only where heavy financial outlay was concerned that I consulted them.

Q. 28. In your letter of March 3rd, 1905, to Mr. Courtney, you refer to Messrs. Sulman & Picard's report of the 3rd inst., and Mr. Higgins' report of the 2nd inst. Are these the reports of those gentlemen bearing the dates mentioned which have been marked for identification during the examination of witnesses in this suit?

1723 A. Yes.

Q. 29. I take it that when Mr. Higgins apprised you of the operations set forth in his report of March 16th, 1905, this was not the first occasion upon which you had been informed of the possibility of using minute quantities of oil in mineral flotation operation; am I correct in this?

A. I had seen the work in progress from about the 1st day of March onwards.

Q. 30. When you saw Mr. Higgins' operations about the 1st of March, 1905, that was not the first occasion, was it, upon which you had been informed of the possibility of using minute quantities of oil in mineral flotation processes; by minute I mean quantities within the range set forth in the patent in suit?

A. No, I had never seen it before within the range of the patent in suit.

Q. 31. You kept in close touch, did you not, with the operations of the technical staff of Minerals Separation, Ltd., including the operations of Messrs. Sulman & Picard?

A. Yes, I did.

Q. 32. That is, you kept fully informed as to the investigations conducted by Messrs. Sulman and Picard and by the staff of Minerals Separation, Ltd.?

A. Yes, as fully as I possibly could.

Q. 33. I presume you frequently visited the laboratories conducted at different times by Minerals Separation, Ltd., and consulted frequently with Messrs. Sulman & Picard?

1724 A. Yes, I consulted with Messrs. Sulman & Picard, especially in the earlier years, almost daily, frequently several times a day, and watched operations carried on in their laboratory, and later on Aldermanbury avenue and the other laboratories that we had. But in later years, of course my work had accumulated so much that I had to leave it to other members of the staff, so that I could not pay the frequent daily visits which I was accustomed to pay, perhaps until October, 1906, when Mr. T. J. Hoover arrived and took up his duties as general manager.

Q. 34. And when you saw the work in progress from March 1, 1905, onwards, as referred to by you in your answer to question 29, was this the first occasion upon which you had been informed as to the use in an oil flotation process of the intentional beating in of air for the purpose of promoting flotation?

A. The intentional beating in of air to produce or promote the flotation of froth which was developed by that process was certainly not known until the fact had been actually discovered that by using a very small quantity of oil, say .2 or .1 per cent., and agitating it

for a certain time, and then leaving the mixture to stand that the whole froth rose to the surface. By "discovered" I mean until the experiments had established the fact that this extraordinary phenomenon was every time reproduced by using the small quantity of oil, violently agitated, and then leaving it to stand, when the mineral rose to the surface in the form of dense froth.

1725 Q. 35. I understand from your last answer that you mean that a discovery was made about March 1st, 1905, and that subsequently the operation was repeated simply to verify the result secured; is this the distinction which you mean to draw between the word "discovered" and the word "established"?

A. The discovery was made about, or soon after, March 1st. And as soon as we had experiments repeated to show that the same phenomenon was constantly reproduced we considered it established and that the principle cause of flotation, or perhaps the entire cause of flotation, was due to air beaten into the pulp, assisted, of course, by the other agents.

Q. 36. What was the result of the thorough overhauling of your patents referred to by you in your letter of March 17th, 1905, to Mr. Courtney?

A. The results were that our patent attorneys very strongly advised us to protect the froth discovery under a patent.

Q. 37. What are the other agents referred to at the close of your answer to question 35?

A. Oil or oleic acid and sulphuric acid.

Q. 38. Did the members of your technical staff, aside from Messrs. Sulman & Picard, ever participate in any of your conferences, or were any suggestions ever made by members of your technical staff?

A. No, I do not think that our members of the staff participated at the conferences between Messrs. Sulman, Picard and myself; while carrying out instructions or experiments, they were naturally

1726 always looked upon as being intelligent people, and were treated as such.

Q. 39. Who were the members of your technical or experimental staff in March, 1905?

A. Apart from Messrs. Sulman and Picard, we had Mr. A. H. Higgins, Mr. John Leechman, and, I think, Mr. A. K. Burn joined us about that time, or towards the end of March.

Q. 40. What were the educational and technical qualifications of these men?

A. I think Mr. Higgins was an associate of the Royal School of Mines, and I think Mr. Leechman was that, too, and had a higher degree, which I do not remember. He is a member of the Institute of Mining and Metallurgy. Mr. Burn, I do not know as to his qualifications. He had his training with Messrs. Sulman and Picard.

Q. 41. In answer to question 37 you mention sulphuric acid as one of the substances included in the term "other agents" appearing in your answer to question 35. In what manner does sulphuric acid contribute to the flotation effect?

A. I believe it keeps the oil from going to the gangue. It also has an effect of settling slime gangue more readily, and by keeping

the oil from sticking to the gangue, naturally it assists the mineral in picking up the very minute traces of oil disseminated throughout the mass of agitated pulp.

Q. 42. The patent in suit gives a range of quantity for the
1727 oleic acid to be used extending from .02 to .5 per cent. in the example set forth in the paragraph beginning at line 70, page 1, the larger quantity being twenty-five times the magnitude of the smaller. In carrying out this process how is the determination to be made as to which of these widely different quantities is to be used?

A. Starting with the small quantity, say at the rate of one pound per ton of ore, an operator can soon tell by the appearance as to whether the characteristic froth is produced or not. Guided by appearances he would either increase or decrease the quantity of oil or oleic acid until the cauliflower or characteristic froth was produced, which in itself will be an unfailing index as to whether or not proper conditions have been attained, and he need only then repeat the measurements quantitatively of oil or oleic acid added to his pulp. Of course I assume that the proper agitation and other factors are satisfactory.

Q. 43. I understand from your answer that the way to carry out the process which the patent purports to set forth, is to operate with varying quantities of oil until what you term the "characteristic froth" appears, and then to keep on operating with the proportion of oil ascertained to have been used in producing such a characteristic froth as you have referred to; am I right in this?

1728 A. In small scale tests the operator would naturally quantify or measure the quantities of oil added, whether they be above one pound per ton or below one pound per ton, and would judge by the appearance of the froth and result when the best proportion had been hit upon.

Q. 44. Would you make a distinction as to the mode of operation upon a commercial scale?

A. On a commercial scale, or before commercial operations are begun, small scale work should, and would invariably, be carried out to determine the best quantities, and the oil supply fed to a commercial plant would be calibrated accordingly, that is, after ascertaining the quantity of ore plus water fed into the plant, the oil feeding apparatus would be set to deliver as nearly as possible the quantities per ton determined by small scale experiments.

Q. 45. In your answer to question 42 and the following questions, I understand that the quantity of oil must be determined experimentally, and that the proper amount of oil is determined by noting the quantity which produces the froth, which you state has certain characteristic qualities. I understand, then, that it is impossible to carry out the process by simply applying the proportions of oil set forth in the patent, and that the final test is not the use of any particular proportion of oil, but the production of the froth; is this correct?

A. The only way to carry out the process is that of applying the proportions of oil set forth in the patent, but to determine, as

1729 all practical men will do, which of the proportions, within the range, yield the best result, the characteristic nature of the froth is always an indicator which will of itself tell an experienced operator when the best conditions have been attained, or having been attained, whether they are maintained in a continuous running, where variations may occur in the feed to the plant of ore and water or pulp.

Adjourned to Tuesday, August 13th, 1912, at 2 o'clock in the afternoon, at the same place.

London, August 13th, 1912.

Met pursuant to adjournment.
Present: Counsel as before.

Direct examination of John Ballot continued:

Q. 46. Did you personally, Mr. Ballot, impart any instructions to Mr. Hyde as set forth in the bill of complaint herein?

A. Except as to discussing general matters with him, I do not think that I personally gave him definite technical instructions.

Q. 47. Will you state the reason why the instruction of Mr. Hyde in his duties was entrusted to Mr. Hoover and Mr. Higgins and others, rather than to Messrs. Sulman, Picard and yourself?

A. Mr. Hoover was our chief engineer at the time, and had the general management of our testing works. Messrs. Sulman and Picard were more in a consultative position at that time.

1730 Q. 48. Did Minerals Separation, Ltd., ever send Mr. Higgins to Australia?

A. Yes, Mr. Higgins was sent to Australia.

Q. 49. At about what time was he sent to Australia?

A. From the summer of 1908 to the spring of 1909.

Q. 50. Was this slide machine to which you have referred necessary in experimentation for the purpose of applying the process of patent 835,120 in practical operations?

A. It was not necessary, but it was a very convenient form of apparatus.

Q. 51. Before the slide machine was designed by Mr. Sulman or Messrs. Sulman and Picard, as the case may be, did you have other mechanism for making tests of that kind?

A. Yes, we had several, the principal was the ordinary gabbet, in which the process was practically originally discovered, which consisted of a single mixing vessel, with a cone agitator and loose baffles slipped over the sides. The agitator was driven either by a small motor direct coupled to the agitator shaft, or by a belt, and the agitation took place, and after a sufficient amount of agitation had been given to it the cone agitator was stopped, and as soon as the contained pulp and water came to a rest the froth always floated to the surface. After leaving it for some minutes, the gangue settled out and the concentrates were either skimmed off by spooning or they were flowed off by inserting a funnel through the froth some

1731 distance into the water below and pouring in more water, so that the gabbet was filled and the froth permitted to flow over the rim of the gabbet, when the products were collected and assayed. The tailings, that is to say, the residues, were drawn off either by pouring off the water or by emptying the residue through an opening in the bottom of the mixing vessel, when a similar operation was repeated, if necessary, and as often as was necessary.

Q. 52. Was the information which you directed Mr. Hoover to impart to Mr. Hyde, aside from the patent in suit, necessary to enable Mr. Hyde to perform the duties for which he was engaged by the Mexican Syndicate?

A. My instructions to Mr. Hoover were to give Mr. Hyde all the information. It is quite possible that some information given may not have been necessary for carrying out his duties, but I thought it was expedient and perhaps also courteous to let our Mexican representative know as much about the company's processes and inventions as possible. Not only to carry out his work, but to get a personal interest in the company and in his position.

Q. 53. Is the Mexican Syndicate still in existence?

A. No, it was taken over by the American Syndicate.

Q. 54. Can you state the substance of any of the technical details and particulars as to letters patent No. 835,120, regarding which Mr. Hyde was instructed in pursuance of your directions, or otherwise?

1732 A. From personal knowledge, I cannot detail particulars, except that the patent was handed to Mr. Hyde. Mr. Hoover was requested to give him all the information necessary. He was given the run of our works to inform himself. As soon as the slide machine was prepared an experienced operator was placed at his disposal in conjunction with Mr. Hyde, to carry out a series of tests. These tests Mr. Hyde carried out, personally informed me that he did so, and sent in a report of the work that he did.

Q. 55. In order to enable Mr. Hyde to apply the process, which the patent in suit purports to set forth, and in order to enable him to determine whether or not that process would be applicable to any ores which he might encounter in Mexico, was it necessary that he should have any special instruction in technical details and particulars as to the patent in suit?

A. If my memory serves me correctly, the patent itself tells him, or would have told him, that different ores required different treatment, that is to say, that the treatment of each individual ore could easily be determined by a few preliminary experiments on the general lines and within the limits directed by the specification itself.

Q. 56. By this do you mean to convey the idea that no instructions were necessary in addition to those contained in the patent in suit in order to enable Mr. Hyde to perform his duties for the Mexican Syndicate?

A. No, I do not wish to convey that idea, without qualification, but to a gentleman experienced in metallurgical practice, as

1733 Mr. Hyde was recommended to me to be, and which I fully believe, but very little additional instruction would be neces-

sary, and although I do not remember definitely that I discussed the details with him, I feel certain that he had all facilities at his disposal in our works, because of his assurance to me before he left for Mexico that he felt himself fully qualified for the work entrusted to him, which naturally involved treating a great variety of different ores.

Q. 57. You say very little instruction, and I assume you mean very little instruction additional to that contained in the patent, would have been necessary to enable Mr. Hyde to perform his duties for the Mexican Syndicate. Will you please specify what this little instruction would have been or was?

A. I do not think any additional instructions were necessary to qualify any one skilled in the art to carry out the process beyond the directions given in the specification, but the little additional instruction necessary in Mr. Hyde's case was to make him proficient as quickly as possible in handling the type of test apparatus which he was to take out, remembering that his time in London was more or less limited, to enable him to acquire the necessary information, before he set out for Mexico.

Q. 58. Then as I understand you, the only effect of instruction given to Mr. Hyde was to impart to him the information which you say is contained in the patent in suit, and to impart that information in possibly a shorter time than you think he might have
1734 secured it from the study of the patent alone without instructions. Is that correct?

By Mr. Williams: Objected to as a misstatement of the witness' testimony.

A. The instructions given to Mr. Hyde embraced all the information we had at our disposal and under my special orders our test works and testing apparatus were placed at his disposal so that it could not possibly have been limited in the form of your question.

Q. 59. Was any of this information which you say was conveyed to Mr. Hyde and was not contained in the patent in suit necessary to enable him to discharge his duties for the Mexican Syndicate?

A. I think I have already answered that question, and I repeat that we felt it necessary for our Mexican representative to have as full a knowledge as possible of the various processes owned by the company.

Q. 60. Mr. Hyde's duties for the Mexican Syndicate consisted in the examination of ores and tailings for the purpose of ascertaining whether or not they were amenable to treatment by the process which the patent in suit purports to set forth, did they not?

A. That constituted part of his duties and of course an essential part.

Q. 61. At the time that you engaged Mr. Hyde for the Mexican Syndicate was it your idea that instructions additional to those contained in the patent in suit were necessary to enable him to perform the duties referred to in question 60 and answer?

1735 A. Apart from that relating to the policy and business of the company I considered it necessary for Mr. Hyde to have

a full knowledge of the methods employed in our London works as well as of the apparatus, and to qualify himself in handling such apparatus before he started for Mexico.

Q. 62. Were the apparatus and methods in use at the London testing plant at the time of Mr. Hyde's engagement by the Mexican Syndicate the same as those described and illustrated in the patent in suit?

A. Broadly, yes. In small scale apparatus there was the modification of the slide machine, also an apparatus attempting to carry out the frothing test on a small scale by drawing off the froth continuously. The larger scale plant was modified to the extent of having three or four single spitz boxes connected with the square agitation vessel by means of a tube some three or four inches in diameter passing from agitator box to frothing box, the tailings being lifted from the frothing box by means of a pneumatic pump, that is, a pump operated by means of air under pressure, into the second agitating vessel, and from there onwards the operation was repeated in the same way, the froth from the first and each spitz box overflowing into a launder which carried the total contents to a collecting box or filter bed as the case may be.

Q. 63. Where was the connection between the agitation vessel and the frothing box, at the top or bottom or where?

A. It was practically at the bottom of the agitation vessel
1736 but entered the spitzkast some distance down. I could produce plans if that were called for.

Q. 64. It entered the frothing box below the water surface therein?

A. Yes, some distance below.

Q. 65. Are you sure that the connection between the agitation vessel and the frothing box was a tube and not simply a hole in the wall that separated the agitation vessel from the frothing box?

A. I am quite sure they were tubes.

Q. 66. Did the small scale apparatus and the larger scale plant referred to in your answer to question 62 operate in substantially the same way?

A. Substantially yes, the same characteristic froth was produced, but the chief difference consisted in the one being a continuous plant and the other intermittent.

Q. 67. In your answer to question 62 I think you refer to an apparatus attempting to carry out the frothing test on a small scale by drawing off the froth continuously, and also referred to a larger scale plant. I meant to inquire as to whether the apparatus first mentioned by me in this question operated in substantially the same way as the larger scale plant referred to?

A. If my memory serves me correctly, in carrying out tests with that small scale plant the prepared froth pulp was fed into the spitz somewhat on the same lines as in the larger scale plant and it was also at times fed on to the surface of the water or a little launder leading on to the surface of the water.

1737 Q. 68. Was the small scale continuous plant as efficient in its operation as the larger scale plant?

A. That particular plant was not and it was soon abandoned, and

the old style of gabbet agitator and skimming off the froth, or the slide machine, were made use of, and at present the slide machine has in London, at least, superseded other small scale testing plants. By testing I mean experimental plants.

Q. 69. Do you mean that Mr. Hyde saw this small scale apparatus from which it was attempted to draw off the froth continuously?

A. Personally, I do not know.

Q. 70. I would like to have you, Mr. Ballot, if you will, describe the mechanism and arrangement of this small scale machine which was designed for the continuous drawing off of the froth?

A. This special small scale apparatus, as referred to as I understand the question, consisted of one square box with glass sides. The agitator was suspended from the top by means of a shaft and had instead of a cone a simple cross made of two crossed blades of metal which formed the beater or agitator. The shaft was driven either by a small motor coupled direct to it or by pulleys. The spitzkast was outside with a small rubber tube connected from near the bottom of the agitation box to the spitzkast, feeding in part of the way down or over the little apron or launder as the case may be. I would here say that I am not sure whether at one time or another this particular apparatus did not consist of two spitz boxes worked side by side with a tube or pipe connection from the one to
1738 the other, the agitated pulp being fed into the spitz at the end of the second box as before described.

Q. 71. In carrying out the process which the patent in suit purports to disclose, what degree of agitation did you give to the oiled and acidified pulp?

A. So far as my memory serves me, various agitators were revolved at different speeds according to their size and the size of the vessel in which they were used, but I think that in practice generally a speed varying from one thousand to sixteen hundred, and sometimes more, peripheral feet per minute is usually found to be an efficient degree of agitation.

Q. 72. How did the degree of agitation imparted to the pulp in the practice of the operations set forth in the patent in suit compare with that used in practicing the Cattermole process which is referred to in the patent in suit?

A. In the Cattermole process, if I remember rightly, there were two degrees of agitation. In the first series of mixers the agitation was fairly violent to disseminate the oil throughout the pulp and to coat the mineral particles. In the second portion of the process a very much slower rolling motion was given to enable the mineral particles to attach themselves to one another and to be rolled into small shot-like granules.

Q. 73. Which of the two kinds of agitation used in the Cattermole process was employed in practicing the operations set forth in the patent in suit?

A. The first, but in a more violent degree, because the
1739 quantity of oil being so much smaller than that used in the Cattermole it required more agitation to disseminate it

throughout the pulp for the purpose of coating the mineral or being attached to the mineral.

Q. 74. In carrying out the operations of the patent in suit is there any relation between the amount of oil used and the viscosity of the oil?

A. I do not think there is any relation as to the viscosity provided the oil is in a thin liquid condition so that it can be easily disseminated throughout the pulp. If an oil like oleic acid were to be solidified or thickened by cold it would naturally be necessary to warm it up to liquefy it.

Q. 75. Has it been your experience that different ores required different amounts of the same oil and that the same ore requires different amounts of different oils in the practice of the operations set forth in the patent in suit?

A. Yes, I think that is so.

Q. 76. I understand that a great deal of your experimentation with the operations of the patent in suit has been conducted upon ore or tailings from Broken Hill, Australia. Did you find that these ores and tailings did, or did not, contain calcite?

A. I believe they all contain calcite, some very little and others a good deal more.

Q. 77. Was the process which was tried at the Minerals Separation plant in Wales adopted by the San Francisco Del Oro mine for the treatment of its ore or tailings at the mine?

1740 A. The San Francisco Del Oro took a license from us but up till now the process has not been installed at the mine because of the fact that its calcite and fluorite contents cause a very heavy consumption of acid which the company think at the present time would not yield them a commercial result if they have to import their acid, as they have to do at present.

Q. 78. During your investigation, that is, the investigations of Minerals Separation, Limited, into the Cattermole process, during the two years or more preceding the year 1905, I presume the Cattermole process was operated under varying conditions as to degree of agitation, amount of acid, oil, dilution of pulp and so forth for the purpose of ascertaining the value of that process. Am I correct in this?

A. That was so.

Q. 79. In some of the documents which have been referred to, Messrs. Sulman & Picard referred to a Mr. Pudsey. Will you state Mr. Pudsey's connection with the work of Minerals Separation?

A. Pudsey was member of Messrs. Sulman & Picard's staff while they were carrying out investigations in the Cattermole process for the owners of the Cattermole process before it was acquired by Minerals Separation, Limited.

Q. 80. Do you know Mr. Pudsey's first name and present address?

A. I regret to say I do not.

Q. 81. Is the plant of Minerals Separation in Wales still being operated?

1741 A. The plant never belonged to Minerals Separation, it was a Minerals Separation plant put up at the request of the

San Francisco Del Oro Company by Minerals Separation for the purpose of producing concentrates from a shipment of several hundred tons of ore sent to England which that company wished to use to test a special zinc smelting process. It was only used to produce those concentrates, which it did successfully, but what has become of it I do not know.

Q. 82. You are the John Ballot who is one of the grantees of the patent in suit, are you not?

A. I am.

Q. 83. During the investigation of the Cattermole process and the development of the process to which the patent in suit relates, did you personally perform any of the experimental work in the laboratory or other plant?

A. No, I never personally carried out any experimental work, that is, I never manipulated the experimentation myself, only directed or assisted in directing the experiments.

Q. 84. Will you state what your education or experience has been as a chemist or metallurgist?

A. I have had no school education in either chemistry or metallurgy except in the elementary stages. My practical experience has been gained over a period of some ten or eleven years while in South Africa at the Witwatersrand gold fields as a mine owner myself or as managing director of several gold-mining companies, where I closely followed practical operations connected with that in-
1742 dustry; and since 1901 I became closely connected, and have ever since followed, the development of oil processes in London, and have been in close touch with chemists, metallurgists and engineers during investigations of such processes, and have been practically ever since, which connection has given me the experience that has enabled me to make Minerals Separation the success it is.

Q. 85. Did any other members of the staff of Minerals Separation, besides Mr. Higgins and Mr. T. J. Hoover, go to Australia under instructions from Minerals Separation, Ltd., in connection with the Cattermole or the flotation process?

A. Apart from Mr. Chapman we sent out Mr. A. H. Higgins and Mr. Rasmus J. Harvey. After that we sent out Mr. A. K. Burn, and Mr. E. H. Nutter was sent out in the early part of 1910.

Q. 86. Can you state the present whereabouts of Mr. Harvey or Mr. Burn?

A. Mr. Harvey is still employed at the Sulphide Corporation, Broken Hill. Mr. Burn, I understand, is at present engaged in the erection of a Minerals Separation plant at the Cuba Copper Co.'s mines in Cuba.

Q. 87. On page 8 of Messrs. Sulman & Picard's report of March 3rd, 1905, addressed to you, I find a reference to "a combination of the float and soap process, i. e., by what is generally known as the Froment process." Did this reference to the Froment process convey a definite idea to you?

1743 A. In connection with the Nagyag ores referred to by Messrs. Sulman & Picard it did convey a definite idea, because the Nagyag ores, if I remember rightly, contained a considerable

percentage of calcite so that by adding a sufficiency of soap the slimes were agglomerated completely and were well agitated to insure their complete intermixture when a small amount of acid was well stirred in and the usual float could be obtained by the Froment process.

Q. 88. When did you first learn of the Froment process, Mr. Ballot?

A. I think it was some time in August, 1903, by publication of an abstract of the specification.

Q. 89. Referring to the operation described in your answer to question 87, what means were employed for stirring the acid into the intermixture there referred to?

A. It is difficult to answer that from memory of that particular experiment, but at that time I know the general practice was to first of all mix the oil and water, etc., thoroughly and then stir in the acid gently by means of a stirring rod.

Q. 90. When did you first learn of the use of oil or fatty matter as a means of producing the flotation of part of the constituents of an ore suspended in water?

A. The action of an oil was first known to me almost in my school-boy days in so far as it relates to the greased needle effect. The accidental flotation of small portions of granulated mineral I think first appeared during the Cattermole investigations.

1744 The flotation of oiled mineral by means of gas chemically generated and liberated in a pulp first became known to me by the Cattermole Sulman & Picard flotation process and the Sulman and Picard process or discovery taken out by them before Froment's patent was published. I have not included the oil buoyancy process of Elmore, which I studied during 1901 and 1902, as being referred to in this question.

Q. 91. Did you ever see a froth produced upon a pulp containing more than 1 per cent. oil, that is, the amount of oil equal to more than 1 per cent. of the ore?

A. I have seen the gas bubble froth effect as produced by the Froment type or the Sulman and Picard's bubble type of process, caused by liberating a gas in the pulp, but I have never seen a froth of the character produced by the patent in suit, with that quantity of oil.

Adjourned to Wednesday, the 14th of August, 1912, at 2 o'clock in the afternoon, at the same place.

1745 London, August 14th, 1912.

Met pursuant to adjournment. Present, counsel as before.

Direct examination of John Ballot continued:

Q. 92. In questions 68 and 70 and the answers thereto as well as elsewhere in your testimony, reference has been made to a small scale apparatus from which the froth was to be taken continuously. Will you state whether apparatus similar in general character to the particular apparatus referred to had previouly been constructed and tried by Minerals Separation, Ltd.?

A. The square box agitator as a continuous plant, but on a much larger scale, was so far as my memory serves me, first introduced at Cowper street. This consisted of a number of agitating boxes in series, the pulp passing from one to another and after sufficient agitation, with of course the addition of the oil and acid and ore, the finished pulp was fed into a spitzkast. At Cowper street also we had a smaller scale plant consisting of a battery of some five or six gabbet mixers from which the pulp, after having received the necessary treatment, agitation, etc., was led into a spitzkast somewhat about half way down so that the discharge took place well under the surface of the liquid in the spitzkast.

Q. 93. Will you kindly state if subsequent to this apparatus constructed on Cowper street still others of the same general type,
1746 whether on a large or small scale, were constructed and tried by Minerals Separation, Ltd?

A. At Charlotte street a large scale plant consisting of six or eight square agitation boxes, I am not quite certain as to the number, was put up, which likewise discharged the finished pulp on to a spitzkast, and the residues from the first spitzkast were dropped on to an apron feeding same into a second spitzkast and I believe later on one or two more spitzkasten were erected below the second one for the purpose of experiment and investigation to determine how far any sunken mineral could be recovered by flotation.

Q. 94. After the construction and trial of this plant on Charlotte street were any more apparatuses of this general type built and tried, prior to the construction of the one referred to in your reply to question 70?

A. I have no distinct recollection of small scale plants such as referred to in question 70, but I do recollect that the larger scale plant referred to in my previous answer was somewhat modified under the direction of Mr. T. J. Hoover simplifying the frothing arrangement very much by making the plant more compact, and resulted in the construction of the larger scale plant referred to in my answer to question 62. I would like to add that research or investigation was going on all the time with a view to discovering a handy apparatus for small laboratory test work that would closely approximate
1747 the operation of the larger scale or commercial plant, but I do not remember details.

Q. 95. How did these various apparatuses which were constructed and tried prior to the apparatus described by you in answer to question 70, compare in the results secured by their operation with the results secured by the operation of the apparatus described in answer to question 70?

A. I do not think the apparatus described in my answer to question 70 was successful or comparative with that of the other continuous apparatus referred to in the question because I understood that its use was very soon abandoned.

Q. 96. In the operation of the apparatus constructed prior to that referred to in answer to question 70, to what extent was the valuable content of the ore recovered in the form of a froth as distinguished from what we have referred to as a film?

A. In answering the question I will take the last part first. I do not understand the reference as to film. The metal content or valuable content were certainly recovered as a froth.

Q. 97. By the term "film" I referred to particles of the metalliferous mineral, sulphides I believe in the ores which you experimented mostly with, which had been oiled and which floated upon the surface of the water, not in the form of a froth containing bubbles and of substantial thickness, say an inch or two, but floating after the manner that a greased needle floats upon the surface of water.

1748 My inquiry was directed to ascertain whether in the operation of these machines constructed prior to that described by you in answer to question 70 more or less of the floating mineral did not take the form of a film, as so defined. With this explanation will you kindly answer the question.

A. In the frothing process film flotation such as you describe in the question under reply, if it took place at all, would be considered as a sure indication that there was something wrong in the preparation of the pulp, either by insufficient agitation, or additions of oil or acid, or in the proportions of ore and water. It is true that at the beginning of a test or towards the end of a test, indications of film may appear, but they only do so because of the altered condition whereby a small quantity of mineral froth is produced, brought on the surface of the spitz water and there possibly spread out by the force known as surface tension.

Q. 98. During the operation of all of these machines constructed prior to the machine referred to in your answer to question 70, did not this film of floating mineral appear at other times than at the beginning of the operation of the apparatus and at the shutting down of the operation?

A. It may have appeared when the conditions were faulty, and in fact it was always an indicator that something was wrong with the conditions of the test.

Q. 99. Did you ever find out what it was that was wrong so that you could operate these apparatuses for long periods, say for a

1749 day, without the appearance of a considerable amount of mineral floating as a film instead of as a froth?

A. I do not think any trouble was ever experienced in correcting it if it appeared at all. In our test plant in London, however, it was not frequently possible, or perhaps possible at all, to run a continuous test lasting over a whole day, simply because ore was scarce and expensive to obtain, and such ore as we had, had to be made use of as carefully as possible.

Q. 100. You qualify your answer by prefacing it that you do not think. Do you state unqualifiedly that the production of this mineral floating in the form of a film as distinguished from a froth, was not a most frequent occurrence and one that engaged your attention and that of your associates and the staff of Minerals Separation in an endeavor to eliminate the film flotation and secure uniform froth flotation?

A. I do not remember any case where we failed in correcting it,

if it occurred at all. The reduction of the area at the spitz box easily regulated that by keeping the froth closer together and preventing it being spread over an unduly large surface of water so that the question became a mechanical one of determining the most suitable spitz area and that was adjusted by having movable boards or baffles which were put in as circumstances required it.

Q. 101. Which machine of those you have referred to was fitted with these movable boards or baffles for the purpose of regulating the area of the spitz boxes?

1750 A. I believe we used these movable boards, either as sheets of glass or as thin wooden strips, even so early as at Cowper street, when the multiple spitz was in use of the character shown in Figure 1 of the patent in suit.

Q. 102. Will you state the period of time that your laboratory was at Cowper street?

A. From June 24th, 1905, to 24th June, 1907, but the dates I give you here were those of the lease of the premises. Charlotte street was taken on the 19th January, 1907.

Q. 103. Please state the period of time during which you occupied the laboratory at Charlotte street and the other laboratories in which flotation investigation was conducted.

A. Aldermanbury avenue, tenancy commenced March 24, 1904, ended June 24, 1905. Cowper street, tenancy commenced June 24, 1905, ended June 24, 1907. Phipp street, an auxiliary laboratory for dry-table experiments, tenancy commenced September 29, 1905, ended September 29, 1907. Charlotte street, tenancy commenced January 19, 1907, ended December 25, 1910. King John's court, tenancy commenced June 24, 1910, and is still continuing.

Q. 104. Will you explain the manner in which these movable boards or baffles were manipulated?

A. They were placed longitudinally across the spitzkast from the side where the pulp entered to the overflow, either one at a time, leaving the one side of the spitz to form one wall of the

1751 partition, or when using two boards they were placed inside the spitz in the same direction so as to narrow the channel along which the froth traveled to the overflow lip.

Q. 105. I will read to you a question that was put to you as a witness, and your answer thereto, in a suit in the King's Bench Division in the High Court of Justice, this suit having been brought by the Ore Concentration Company, Limited, against Webster and others, including yourself, and ask you whether in that suit you did in fact answer such a question in the words which I now read to you? The question and answer are as follows:

"1062. Just tell his Lordship why your name is mentioned in some of these patents, the first one is, I think—if I am wrong correct me—an application of the 13th January, 1905, 1821 of 1905. The applicants are Sulman, Picard and Ballot. Then you come into some others. How was it your name comes into those patents?—First because I was chairman of the Minerals Separation, and when these inventions were made I was specially directed by the directors

of Minerals Separation to have my name added to it as a matter of extra protection for the company.

"1063. You yourself taking an interest in the development of these patents?—I took a very considerable interest in it, closely watching the better part and watching everything that was going on.

"1064. You mean the experiments?—In the experiments,
1752 and naturally suggested anything and everything that I could think of."

A. Yes.

Q. 106. One of the issues of the suit from which I have quoted your testimony was the ownership of, or rights under, certain patents in which the Ore Concentration Company, Limited, claimed an interest, was it not?

A. I think I should have the opportunity to refresh my memory before I answer these questions.

Q. 107. The controversy in this suit from which I have quoted part of your testimony involved certain patents which the defendants, Webster, Godlonton and yourself either owned or had an interest in, did it not?

A. Neither Webster, Godlonton nor myself owned any patents.

Q. 108. Can you state in a general way what the suit from which I have quoted your testimony was about, and to what extent any patents were involved in that controversy?

A. The object of the suit was to enforce an old contract under which the defendants took an option from the Elmores for their Australian rights of their bulk flotation oil process in 1901 to October, 1902, and claiming under that contract that the patents then owned by Minerals Separation, Limited, were the property of the defendants and should be assigned to the complainant.

1753 Q. 109. Among the patents so owned by Minerals Separation, Ltd., was there included the British patent containing the subject-matter of the United States patent 835,120 involved in the suit in which you are giving your deposition?

A. I believe so.

Q. 110. From your testimony above quoted I understand that in some cases your name has appeared as a grantee of British patents in cases where you were not the inventor of the subject-matter thereof, as I understand is permissible under the British law. Am I correct in this?

A. As a matter of fact I do not believe that my name has appeared in any cases in the invention of which I did not participate.

Q. 111. The reason which you give in your testimony quoted above why your name appears upon the patents therein referred to is that you were chairman of the Minerals Separation and were specially directed by the directors to have your name added as a matter of extra protection for the company. That would be sufficient reason in itself, would it not?

By Mr. Williams: Objected to as not properly stating the subject-matter of the testimony referred to.

A. That was not the reason why my name appeared in the patent in suit or the corresponding British patent. What I stated to the court at that time was perfectly true, that the board of the
1754 company thought it advisable for me to have my name added to patents, but our patent agents advised differently, as is evidenced also by a number of patents owned by our company on which my name did not appear.

Q. 112. So far as British patents were concerned it would have been perfectly proper for the application to have been made in your name and for the grant to have been made to you regardless of whether or not you were the inventor or one of the inventors?

By Mr. Williams: Objected to as incompetent, the witness not having qualified as an expert having knowledge of British patent law. The offer is made to stipulate as to what is the law and the witness is directed not to answer the question.

By Mr. Scott: Question withdrawn.

Q. 113. What part did you have in the invention of the process claimed in United States patent 835,479 and the corresponding British patent?

A. It is impossible to tell you what particular part I had in the invention as Messrs. Sulman, Picard and myself collaborated and consulted daily and between the three of us we undoubtedly evolved the process and the apparatus.

Q. 114. Do you remember with whom the idea of using gas pressure as set forth in the claims of this patent, originated?

A. No, I do not remember. It was the product of our joint conferences or consultations.

1755 Q. 115. Do you remember that you had any part personally in originating the idea of using gas pressure?

A. It is impossible to differentiate the part I had in it from any part by Sulman and Picard.

Q. 116. I notice that the process of this patent is defined in the first claim as consisting of suspending the powdered minerals in a liquid, subjecting the mixture to a gas pressure and thereafter relieving the pressure. From your testimony regarding your familiarity with the metallurgic art I assume that at the date of the invention set forth in the patent 835,479, the idea of suspending powdered minerals in liquid was known to you to be very old, was it not?

A. Yes, if translating it into plain language you mean finely pulverized or crushed ore whether crushed dry or wet: if crushed dry to mix it with water, thereby suspending it in the liquid.

Q. 117. And you cannot state who originated the remaining steps set forth in this claim, namely, submitting the mixture to a gas pressure and thereafter relieving the pressure?

A. I can only say that Sulman, Picard and Ballot did it jointly.

Q. 118. You cannot state any facts, then, upon which you base your conclusion that this idea of subjecting the mixture to gas pressure and thereafter relieving the pressure was done by yourself, Messrs. Sulman and Picard jointly?

1756 A. I remember distinctly that we experimented with a soda siphon, put the charge in that, with sufficient quantities of oil and acid, then pumped in air, and then quite easily shook it, agitating it by shaking with the hand, and liberating it by discharging the contents into a separate beaker, when the flotation effect was noted. Later on we broke off the stem just below the neck of the bottle, put in the charge into a partially filled siphon, agitated it and simply let off the pressure by touching the lever. (Witness illustrates with a siphon of soda water.)

Q. 119. Do you remember who first performed this experiment with the soda siphon?

A. I do not remember at all.

Adjourned to Thursday, August 15th, at 3 o'clock P. M., at the same place.

London, August 15th, 1912.

Met pursuant to adjournment.

Present: Counsel as before.

Direct examination of Mr. Ballot continued:

Q. 120. When did you first see a demonstration of the process which the patent in suit purports to set forth?

A. If by demonstration you mean the phenomenon of the mineral contents rising to the surface in the form of a froth, I first saw that somewhere between the 3rd and 10th of March, 1905, while Mr. Higgins was carrying out the programme of work set him by
1757 Sulman, Picard and myself, and especially while he was step by step reducing the percentage of oil used in the experiments.

Q. 121. And who was present upon this occasion?

A. On the first occasion I think Mr. Higgins and myself and possibly Mr. Leechman, but I am not sure of that.

Q. 122. How did you happen to be present?

A. Simply because I was closely interested not only in the special programme of work set Mr. Higgins by Sulman, Picard and myself, but in all research or experimental work being carried out, and I made it a daily practice of visiting the test works at Albermanbury avenue, sometimes more than once a day, and I also as often as possible visited Sulman and Picard in their own laboratory where they were carrying out investigations, and I was naturally anxious to see the developments of the experiments or tests, I do not know the exact word, carried out by Mr. Higgins, especially so because during the earlier part of his experiments when he had reached the limits of about .5 to .6 per cent. considerably more mineral float appeared on the surface, which rather puzzled us.

Q. 123. Can you state approximately the date when you received the description and instructions, accompanied with drawings, from Mr. Froment?

A. These were received at my office about December, 1903.

Q. 124. It was at least as early as December 30th, 1903, was it not?

1758 A. Yes, that is so.

Q. 125. Will you state, if you can remember, what kind of an apparatus Mr. Higgins was using in his work at the time he was reducing the amount of oil, as you have stated?

A. He used what we generally describe as a single gabbet, which consisted of a cylindrical vessel with a hemispherical bottom set in a brass mounting. The agitation was performed by means of a cone mounted on a shaft, suspended into the gabbet and driven either by a small motor, coupled direct to the shaft, or by a belt and pulley, and over the sides of the mixing vessel four movable baffles were adjusted so as to reach down on the inside of the mixing vessel well into the pulp contents of the charge. These baffles just described were at will removed or reintroduced in the course of the operation, as the operator desired.

Q. 126. Is Mr. Higgins to whom you have referred still employed by Minerals Separation, Ltd.?

A. Yes, he is.

Direct examination closed.

Cross-examination.

By Mr. Williams.

X Q. 127. You have spoken of a programme of work set for Mr. Higgins by Messrs. Sulman, Picard and yourself. In what manner, if you know, were instructions transmitted to Mr. Higgins to carry out this programme of work?

A. Program was prepared by us in writing and that was handed to Mr. Higgins by Mr. Sulman in my presence.

1759 X Q. 128. Has Mr. A. Howard Higgins ever to your knowledge claimed to be the inventor of the agitation-froth process of the patent in suit?

A. No, sir, he has not, and he has placed on record a confirmation of this in an affidavit sworn to by him.

By Mr. Scott: The preceding answer is objected to as secondary evidence in that the affidavit referred to is the best evidence of what Mr. Higgins set forth therein.

X Q. 129. In Q. 6 you were asked to state any particular or specific instructions which were given to the defendant as to the technical details and particulars relative to the letters patent in suit and the installation and use of the process of ore concentration constituting the invention set forth in that patent, and in that and succeeding answers you confined yourself to what took place before Mr. Hyde went to Mexico. Have you anything further to add as to such instructions after Mr. Hyde had left London to go to Mexico?

A. While Mr. Hyde was absent in Mexico, the United States and Canada, he was continually informed of how to test certain ores and what particular oils to use in experimenting with the same. In short,

he was kept fully informed of everything that we thought it necessary or expedient that he should know or be informed upon. On his return to London we placed at his disposal all Mr. Nutter's reports on the Australian plant and position, as well as a particular
1760 document dealing with the future development or technical development of Minerals Separation process dated 3rd December, 1910, which document I now produce. He was also shown our new works at King John's court with all the plant as then at work including the froth-trap apparatus which was specially designed to produce a high recovery but a low grade concentrate, the object and intention being to retreat these low grade concentrates by flotation in the ordinary way, and in general I discussed with Mr. Hyde even such confidential matters as the appointments of agents in the United States and requested him to give me his opinion, which he did in writing. I also requested Mr. Hyde to bring up a memorandum as the result of his investigations and experience on the North American position with a view to carrying on an active campaign in the countries included, under his own supervision as one of several technical engineers we had in view for the purpose. I now produce this document dated the 8th January, 1911, and signed by Mr. James M. Hyde.

At the request of counsel for the complainants the Commissioner marks for identification the two documents produced by the witness as "Nutter Report December 3, 1910," and "Hyde Report January 8, 1911."

X Q. 130. You have spoken of a Mexican syndicate. How long did this syndicate continue in the form in which you have described it?

1761 A. It continued during the greater part of the year Mr. Hyde was with us, when it was acquired by Minerals Separation American Syndicate, Limited, one of the complainants, soon after October, 1910. The formal agreement was signed on January 12, 1911.

X Q. 131. When Mr. Hyde was sent to Mexico with testing machines of the slide type, as you have testified, were any instructions given to him as to these machines, with a special regard to publicity of their exhibition and use?

A. He was requested by me to keep the machine as confidential as possible and even if need be to get a special room in which to carry on his test privately. The machine itself had not been patented by us and we naturally did not wish too much information to be given to the public on that account. I would add that when he left our service he was requested to immediately return the machine to our custody or to that of our agents. This I believe was done in the course of time.

X Q. 132. In connection with the description and drawings received from Mr. Froment, did you receive any apparatus from him?

A. Yes.

X Q. 133. Have you made a search for this apparatus and can you produce it?

A. I have had a search made but it could not be found, and I fear it has been scrapped.

X Q. 134. Please describe this apparatus received from Mr. Froment.

1762 A. The apparatus consisted of a round or cylindrical mixing vessel, mounted on three or four legs. It was built of sheet iron, and as a mixer it was fitted with an arrangement consisting of two beaters made of stout wire, somewhat like grid-irons, but so arranged that while revolving in opposite directions, the wires freely passed between one another. I could perhaps better illustrate it by referring to a common form of egg beater. These agitators were driven by a suitable gear, and the mixing vessel was fitted with a discharge tap. The next part of the apparatus consisted of a circular tank. Into this was fitted a coil of lead pipe, with one end projecting above the rim of the vessel. The coil itself was placed near the bottom, and the pipe was perforated with small holes. In addition to this, there was fitted to this tank an apparatus resembling a rake, which was fixed to a vertical spindle. This spindle was mounted from bearings over the tank, and, if I remember rightly, had a handle fixed to the upper end, with which to revolve it in operating the plant. The third part of the apparatus consisted of a rectangular wooden tank or box, into which was fitted, just about the water level, a sheet of perforated aluminum, which was connected with a mechanical device overhanging the tank, in such a way that it could be freely rocked or shaken by means of a series of impacts imparted to a spring. The gear giving the impacts was, I think, arranged outside, to be driven by hand. This, I believe, generally described the apparatus we received from Mr. Froment.

1763 X Q. 135. What was the final outcome, and what in general the proceedings in the suit referred to in Q. 105, and a few succeeding questions?

A. There were two trials and one appeal. At the second trial the plaintiffs, through their counsel, withdrew their allegation and publicly apologized, and the suit was discontinued.

Cross-examination closed.

Redirect examination.

By Mr. Scott:

R. D. Q. 136. Referring to the document which has been identified as Nutter Report, December 4, 1910, will you state what Mr. Nutter said about how greatly the recoveries were affected by variations in the rate of addition of oil and acid, this matter being referred to by him on pages 27 and 28, as having been the subject of a previous report, and will you produce that report?

A. I now produce Mr. Nutter's report, dated July 28, 1910, entitled "A Report on the costs of construction and operation of the Minerals Separation Plant at Broken Hill, N. S. W.," which contains, under the heading of "Recoveries," the subject-matter inquired of in the question.

At the request of counsel for complainants, Commissioner marks for identification the report just produced by the witness as "Nutter Report, July 28, 1910."

1764 R. D. Q. 137. What is the source of your information or belief that the document identified as "Nutter Report, December 3, 1910," was placed at the disposal of or seen by Mr. Hyde, the defendant?

A. I instructed Mr. Nutter early in 1911 to supply Mr. Hyde with a copy. Mr. Nutter informed me that he had only one copy left of his own, but he would pass that on to Mr. Hyde. Mr. Hyde himself soon after informed me that he had received it from Nutter and had carefully studied it.

R. D. Q. 138. After the acquisition of the Mexican Syndicate by Minerals Separation, American Syndicate, Ltd., was the contract or arrangement with Mr. Hyde, the defendant, reformed or modified in any way?

A. No, sir, and Mr. Hyde was paid by check by the Minerals Separation, American Syndicate, and accounted for monies received and rendered his final account to that corporation. I have the accounts and checks here.

Redirect examination closed.

Recross-examination.

By Mr. Williams:

R. X Q. 139. During your redirect examination you examined a file marked "Reports by E. H. Nutter." After having refreshed your memory, please state whether or not any one of these reports to Mr. Nutter was not shown to Mr. Hyde?

A. The report headed, "A Report on Administration Staff and Increase of Business in Australia" was not shown. A memo-
1765 randum from Mr. Nutter, headed "Memorandum," and signed "Edward H. Nutter," on the American business, was not shown to Mr. Hyde. A memorandum by Mr. Nutter in the treatment of the disseminated ores of Utah, Arizona and Nevada was not shown to Mr. Hyde.

R. X Q. 140. Can you state any reason why the three documents last referred to were not shown to Mr. Hyde?

A. The report first referred to was not shown because it dealt with the Australian business and staff, which would not in the course of business have formed any part of Mr. Hyde's duties if he had continued his engagement. The second report referred to was a report made to me by Mr. Nutter as setting forth his views of handling the American business, and was a technical report for my private guidance, and for the guidance of the Board, in the same way as we had Mr. Hyde's report on the same subject of January 8, 1911. The third report referred to was probably of later date, after Mr. Hyde had left us.

R. X Q. 141. Now as to the report of Mr. Nutter, dated July 28,

1910, which you have produced, please state whether or not this report was shown to Mr. Hyde?

A. It was.

R. X Q. 142. Did you have any discussions with Mr. Hyde while he was in your employ as to the metallurgical situation in Butte, Montana; if so, please state their substance?

1766 A. I had, early in January, 1911. You will notice that Mr. Hyde in his report of January 8, 1911, referred to Butte, Montana, in two places. The reason why I had a discussion with him about that was that during the latter part of 1910 Mr. Kuehn called on Mr. T. J. Hoover in his room at Minerals Separation offices. Mr. Hoover came to my room and asked me to come into his office, where he introduced Mr. Kuehn to me, and then mentioned that Mr. Kuehn had reported to him that there was a big mine at Butte, Montana, having a large body of zinc ore. We then both discussed it with Mr. Kuehn, and if I remember rightly, Mr. Kuehn told us that this had been a copper mine, but it had turned into a zinc mine lower down; at any rate, we thanked him for the information, and asked him to give us further particulars if he could do so, so that the existence of Butte and Superior was well known to Mr. T. J. Hoover and myself at the time. Hence I discussed it with Mr. Hyde, believing that he would be the engineer shortly to be entrusted with the development of our business in North America. I would refer also to a letter written to Mr. Hyde about the 23rd November, 1910, while he was still in America.

R. X Q. 143. Is the letter last referred to by you the letter referred to in X Q. 72 of the deposition of the defendant, Mr. Hyde?

A It is.

Recross-examination closed.

Adjourned to Saturday, the 17th of August, 1912, at 10:30 in the morning, at the same place.

1767 Redirect examination.

By Mr. Scott:

By Mr. Scott: Now comes the defendant and objects to the answer of the witness to cross-question 129, and to cross-question 139, and the answer thereto, and to all of the testimony of this witness regarding alleged disclosures made to defendant, this objection being based upon the ground that all of such testimony is incompetent, irrelevant and immaterial, having no tendency to prove or disprove any matter at issue in this suit; upon the further ground that the testimony given in response to cross-questions 129 and 139 is irrelevant, immaterial and incompetent, and is further vague and trivial in that it does not appear from the witness' answer what is alleged to have been shown to the defendant, by reason of which vagueness in the witness' statement the defendant is denied the possibility of ascertaining the truth or falsity, as the case may be, of the witness' statement regarding alleged documents which have not been submitted

to his inspection, and which the complainants refuse to so submit to the defendant for his inspection.

Notice is now given to the complainants that at the final hearing of this suit, or at some earlier date, of which due and timely notice will be given, a motion will be presented to the court that all of the testimony above referred to be expunged and stricken from the record.

Defendant further demands that complainants deliver over
1768 into the custody of the Commissioner, by whom this proceeding is being conducted, all of the documents or papers of whatsoever character, the witness had in his possession and referred to during the giving of his testimony, in order that such documents and papers may be held by the Commissioner, subject to such rule as the court may enter upon the motion, of which notice is given above.

By Mr. Williams: The objection above stated, inclusive as it is of "all of the testimony of this witness regarding alleged disclosures made to defendant," is broad enough to include the answer of the witness to Q. 6, wherein he was asked by defendant's counsel to state any particular or specific instructions given to the defendant Mr. Hyde as to the subject-matter inquired of, and the demand is therefore that all of the confidential files of the complainants which were submitted to the inspection of the defendant, when he was employed in a confidential relation to the complainants, shall be now again opened to his inspection, when his position has materially and substantially altered. Cross-question 129 merely called for a further elaboration as to the subject-matter inquired of by defendant's counsel in Q. 6. In R. D. Q. 136 the witness was asked to produce a report specifically referred to in the Nutter Report of December 4,
1910, and the answer to this question of necessity required
1769 a search for this report, and this report "Nutter Report, July 28, 1910," was produced. The situation appears to be that the defendant has inquired of his own witness as to certain facts, and has been replied to more fully than he expected, but the suggestion that these proceedings warrant a reopening to the defendant of all of the confidential documents of the complainants is obviously one which should not meet with the approval of this court, and obviously also there is no occasion for placing all of these confidential documents in the custody of the Commissioner. The witness is now before the Commissioner and ready to answer any inquiries relevant or material to the issues of this suit, and the documents produced and identified will be offered in evidence during the taking of complainant's rebuttal testimony.

By Mr. Scott: While mindful of the fact that this is not the occasion for argument, defendant insists upon his objection and demands that all papers referred to by the witness as having been shown to the defendant be either produced for defendant's inspection now, in order that defendant may govern his further action in this suit accordingly, or that the papers be delivered into the custody of the Commissioner pending the court's ruling upon the motion, of which notice is above given.

By Mr. Williams: No further documents than have already been produced will be produced, under existing conditions.

1770 R. D. Q. 144. Will you state the date upon which Minerals Separation, Ltd., purchased the British patent to Froment, No. 12,778, of 1902?

A. In October or November, 1903. By referring to the agreement, I find it to be the 17th November, 1903.

The Commissioner notes that the witness produces a document, and the same is marked for identification, "Assignment Froment to Ballot, 17th November, 1903."

R. D. Q. 145. I presume the assignment of this patent from Mr. Froment to yourself was made to you for the benefit of Minerals Separation, Limited, was it not?

A. Minerals Separation was not registered at that time, but the assignment was made to me, acting for and on behalf of the group of individuals who had acquired the Cattermole patents, and also some Sulman & Picard patents, which were taken over by Minerals Separation, Ltd., as soon as that company was formed. In fact, the Froment patents were acquired with the object of passing to Minerals Separation the moment that company could be formally registered.

R. D. Q. 146. And it was so assigned?

A. Yes, it was so assigned.

R. D. Q. 147. Were any tests made of the Froment process before the Froment patents were purchased by you on behalf of the parties you refer to?

1771 A. Tests were naturally made by Sulman & Picard which led them to discover their own independent invention during July, 1903, and before the existence even of the Froment patents was known, and as soon as publication of Froment's patents took place, tests were carried out in small scale apparatus, according to that specification, that is, according to the directions given by the patentee.

R. D. Q. 148. Did you find it necessary to have Mr. Froment come to England, or to send someone to Italy, to negotiate the purchase of his patents?

A. I personally negotiated the purchase of Mr. Froment's patents with him in Italy, at Turin, as set forth in the assignment of his patents, and while there I naturally asked Mr. Froment to give me all possible information, and also I asked him to send us plans and drawings, together with clear and definite instructions, as well as to have a model plant built and shipped to England for the purpose of carrying out his process as he recommended it should be done. This he promised to do, with the result that towards the end of the year the plans and instructions were received, and sometime early in 1904 the plant itself was received in London.

R. D. Q. 149. Did you have any negotiations with Mr. Froment prior to going to Turin yourself for that purpose?

A. I think it was in the early part of August, 1903, we sent Mr. Freymuth to Italy to find out Mr. Froment's whereabouts

1772 and to open negotiations with him, but Mr. Freymuth, although he found Froment, failed in bringing about any negotiations, so we instructed our patent agents in London to open negotiations through Mr. Froment's patent agent, Mr. Zanardo, of Rome, and that gentleman secured an option which led to me going to Turin later on to meet Mr. Froment and Mr. Zanardo at Turin by appointment.

Redirect examination closed.

Deposition closed.

JOHN BALLOT.

Adjourned to Thursday, August 22nd, 1912, at 10:30 in the morning, at the same place.

London, August 16th, 1912.

Met pursuant to adjournment.
Present: Counsel as before.

HERBERT CLARK HOOVER, a witness produced on behalf of defendant, having been duly cautioned and sworn, testifies as follows:

Direct examination.

By Mr. Scott:

Q. 1. What is your name, age, residence and occupation?
A. My name is Herbert Clark Hoover; my age is 37; my occupation is a mining engineer, and my residence is the Red House, Horton street, London, W.
Q. 2. Are you acquainted with Mr. Hyde, the defendant in this suit, and if so, for how long have you been acquainted with him?
1773 A. I have known Mr. Hyde about sixteen or seventeen years.
Q. 3. Did you ever engage Mr. Hyde as an engineer?
A. I engaged Mr. Hyde as an engineer for certain companies with whom I am associated in February, 1911. He was engaged in a general capacity of a mining engineer, and I think that he was in work in London about a month, and I asked him to accompany me to New York, as I had some mining business in Alaska and elsewhere that I wished his assistance with.
When I arrived in New York, Mr. A. Chester Beatty, with whom I have been associated, told me that he had looked into some business in Butte, Montana, in connection with a mine called the Butte and Superior, and at his instance I had some discussion with Mr. Stone, of Hayden, Stone & Co., as to the refinance of this company. As a result I detached Mr. Hyde from the other work which I had in view and asked him to go to Butte in conjunction with Mr. Kuehn in the examination of the Butte and Superior mine. My instructions to Mr. Hyde were that he was to take part in the examination of the

mine, and particularly to look into the metallurgy of their ore. As the ore was a zinc ore, I told him to try all the various flotation methods and to report to me what the results were from this or any other metallurgical method that might suggest itself. While in London previous to going to New York, I had placed before Mr. Hyde the whole of the information and experience which I
1774 had in connection with flotation methods other than those of the Minerals Separation Company, that is, the methods of De Bavay Potter, the Delprat and Elmore. Also I had placed before him the whole of the inquiry which I had had made into the Everson method, and in giving him his instructions with regard to the Butte and Superior I told him to try any or all of these methods, or anything else that suggested itself. Subsequently Mr. Hyde reported to me his opinion on this ore from a flotation point of view, but at that time it appeared to me that I had been left out of the financial end of the business, and as I recollect it, I told him that I was no longer interested, and he could do as he liked in connection with this business. So far as I was concerned, I closed my connection with the matter.

Q. 4. Have you had any experience in putting into practice, or having put into practice, the Minerals Separation or Potter or Elmore process, to which you have referred?

A. Yes, I have been for many years the managing director of the Zinc Corporation, which is a company who have used these processes or methods on a large scale, and I have also been largely interested in the Amalgamated Zinc Company, who use flotation methods, and at one time I was interested in both the Potter Company and the Minerals Separation Company.

Q. 5. Was any effort made to have the process being exploited by Minerals Separation, Ltd., introduced into use by the Zinc Corporation, and if so, will you state what took place?

1775 A. In 1905 I first went to Broken Hill and took up the question of organizing the treatment of the zinciferous dumps and tailings from the Broken Hill mines, and did on account of myself and associates purchase large quantities of these materials, which were ultimately transferred to a company called the Zinc Corporation. At that time there were three flotation methods being exploited in Broken Hill, and I visited all of the plants. The Mineral Separation Company were operating the Cattermole process on the Central mine, the Block 14 Company were running a small plant on the Potter line, and the Broken Hill Proprietary were operating the salt cake or Delprat method. I engaged a metallurgical staff, and we delegated them to the inquiry as to which of these methods we should adopt, and they adopted the Potter method. I might add also that the De Bavay method was also used at this time on the Broken Hill north mine. The Zinc Corporation installed the Potter method in their plant, and it subsequently proved a commercial failure. I went *to* London to Broken Hill again upon this event in the winter of 1907, and upon my instructions the mill was altered on to the methods in use by the Minerals Separation Company. These alterations were designed by the engineers of the Minerals Separation

Company, and the plant was installed under their direction. They furnished us with a number of employees of experience to operate the plant, and in a general way had the supervision of its operation.

This plant also proved a failure. After exhaustive trials of
1776 the method we took up the Elmore method and found it successful, we subsequently built a much enlarged and very extensive mill on this line and operated it until some time in 1910. During a considerable portion of this period my brother, Mr. Theodore J. Hoover, had been acting as the general manager of the Minerals Separation Company, and he insistently presented to me the fact that he had made such alterations in the Minerals Separation method that the results were superior to those which we were obtaining by the Elmore method, and upon his insistence I had the matter reinvestigated. We carried out extensive trials with the modified plant of the Minerals Separation Company, and ultimately threw out the Elmore and re-adopted the Minerals Separation.

Q. 6. Is the Elmore process to which you have referred that which is sometimes called the Elmore vacuum process?

A. Yes.

Q. 7. Will you describe roughly the form in which the concentrate was recovered in these various processes, the Potter, Delprat, Elmore and Minerals Separation?

A. All of the processes, so far as I understand them take off a scum or a froth over some form of spitzkasten.

Direct examination closed.

1777 Cross-examination.

By Mr. Williams:

X Q. 8. What process is now in use by the Zinc Corporation?

A. The method exploited by the Minerals Separation Company.

X Q. 9. And, as I understand it, the Zinc Corporation have taken a license under the Minerals Separation patent, and pay a royalty to Minerals Separation, Ltd., based upon the tonnage of concentrates produced; that is true, is it not?

A. That is true. We took out such a license, but I do not want this construed as an opinion on the validity of their patents. The motives which guided the Zinc Corporation Board in taking out such a license were, first, the desire to reward the improvements in metallurgical practice, and, secondly, to have some responsible party who would guarantee the corporation immunity from litigation by the several other claimants to patent rights in these processes.

X Q. 10. And it is true, is it not, that when you first installed the Minerals Separation process your company, the Zinc Corporation, took out a license under these patents of Minerals Separation, Ltd.?

A. They did.

X Q. 11. It is also true, is it not, that the Zinc Corporation paid to Minerals Separation, Ltd., the sum of one thousand five hundred pounds in settlement of royalties due for the work done by Zinc Cor-

potation under the first installation of Minerals Separation plant?

1778 A. Some sum of money was paid, I do not recollect the exact amount.

X Q. 12. Could you give me a rough idea of the total annual payment of royalty made by the Zinc Corporation to Minerals Separation, Ltd., under the existing license agreement?

A. Our production amounts to roughly 90,000 tons of concentrates per annum, and we pay two shillings and sixpence per ton royalty.

X Q. 13. What in full were the reasons which induced the Zinc Corporation to throw out the Elmore vacuum process and readopt the Minerals Separation process?

A. In the main we changed methods because it was possible to treat a larger proportion of slimes in the Minerals Separation method than in the Elmore. While we could secure much the same extraction by both methods, the gangue slimes came over to a greater extent with the concentrates in the Elmore method, and consequently the concentrate secured by the Elmore was of lower grade.

X Q. 14. It was also true, was it not, that with the Elmore vacuum process you had been treating a high grade of ore, and that this high grade ore was very nearly exhausted?

A. The coarse material was at the same time the high grade material, and we had with the Elmore method exhausted a large proportion of our coarse material.

X Q. 15. On the other hand, as I understand it, the Min-
1779 erals Separation process has treated in a very satisfactory manner the lower grade and fine material, which was not profitably treatable by the Elmore vacuum process; this is true, is it not?

A. The first portion of the statement is true. The Minerals Separation process has treated the finer material more satisfactorily, but I would not add that this material was unprofitable by the Elmore method.

X Q. 16. Perhaps we had better say not so profitable; would this be correct?

A. Yes.

X Q. 17. In the Minerals Separation process as now carried on by the Zinc Corporation, what reagents are used?

A. Sulphuric acid and oil.

X Q. 18. And, as I understand it, the mineral pulp is vigorously agitated with sulphuric acid and oil, and flows into a spitzkasten, upon the surface of which appears a mineral-bearing froth, which is separated as the concentrate?

A. It does.

X Q. 19. At the time when Zinc Corporation first adopted a Minerals Separation process the process adopted was also one which would be describable by the language of my last question; this is true, is it not?

A. That is true in general lines.

X Q. 20. At the time that Zinc Corporation discontinued the use of the first Minerals Separation plant, the Minerals Separation pro-

cesses were in successful use, were they not, at Broken Hill, Australia?

1780 A. The process was not a commercial success in our plant, and I was advised that it was not a commercial success in other plants. I, however, cannot speak of this of my own knowledge.

X Q. 21. Could you, without betraying any confidence, tell me who gave you such advice?

A. Our manager, Mr. Mitchell.

X Q. 22. You saw this Minerals Separation plant in operation at the Zinc Corporation works, did you not?

A. I did.

X Q. 23. What was the normal capacity of this plant?

A. If you refer to the first installation, as I recollect it, the capacity was designed for four hundred tons per day.

X Q. 24. What was the financial condition of Zinc Corporation at the time that it made the change from the first Minerals Separation processes to the Elmore vacuum process?

A. The company had been practically bankrupted by the trial of the Minerals Separation process.

X Q. 25. How long was the Minerals Separation process tried at that time?

A. My impression is that we were engaged in operating the process some four or five months.

X Q. 26. And before that how long were you engaged in trying the Potter process?

A. We had it in operation about three months, I should think, in the completed mill.

X Q. 27. And it was an incident, was it not, accompanying

1781 the change from the first Minerals Separation plant to the Elmore vacuum process that Zinc Corporation floated a considerable quantity of preference shares of stock?

A. Yes, we were compelled to raise more capital to reorganize the business again.

X Q. 28. You have spoken of certain improvements made by your brother, Mr. Theodore J. Hoover, in the Minerals Separation procedure. What, if you know, were these improvements?

A. They were largely in the direction of the mechanical devices in which the process was carried on. I do not pretend to have any great technical knowledge in the matter of these processes. My interest has always been on the commercial side.

X Q. 29. You have said that the first Minerals Separation plant was installed under the direction of the engineers of Minerals Separation. Who were these engineers, if you know?

A. Mr. Chapman was the principal gentleman with whom I came in contact.

X Q. 30. What in round numbers was the cost of the Elmore vacuum plant which was superseded by the Minerals Separation plant now in use?

A. This will require some explanation. We built a de Novo mill,

with a new power plant, a new crushing plant, with railways, and so forth, together with a reconcentration plant, the whole cost running into probably £140,000. This mill had a capacity of about 1,000 tons per diem. When we introduced the Minerals Separation method the last time we spent something like £30,000 on the alterations. I do not exactly remember the figures, the above are approximations.

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X Q. 31. I have here what has been handed to me as the original table of the results and material treated by Zinc Corporation on the first installation of Minerals Separation plant during the period from May 2 to June 8, 1907, which shows a tonnage treated of 8,675, and concentrates produced as 1,891 tons, and which appears to show profitable operations.

A. I cannot identify the table. I do not assume that this was the total tonnage treated, or we should not have paid £1,500 in royalties on any such tonnage of concentrate. During the time that the mill operated the results were very erratic, and I do not know that on continuous occasions we came any way near the promised tonnage. I certainly do know that the plant was not operated at a profit.

X Q. 32. Is it not a fact that the ore crushing facilities used in connection with this plant were inadequate?

A. According to the Minerals Separation Company's engineers, when they designed the plant, they were adequate. I recollect that subsequently the head tonnage was greatly reduced below the anticipated capacity in order to determine if this was the difficulty, and our engineers advised us that it was not.

X Q. 33. It is true also, is it not, that on one occasion, when Mr. Chapman was present the plant was run under your direction up to 500 tons per day capacity, with the result that the mineral was not properly treated?

1783

A. It is true that the plant was run at its anticipated capacity and proved wholly a failure at such a tonnage. The tonnage was subsequently greatly reduced without better results, from a commercial point of view.

X Q. 34. What is the metallurgical situation in Broken Hill, Australia, which has brought about the great quantity of tailings, now being treated for the extraction of valuable mineral therefrom?

A. Well, over a period of many years the Broken Hill mines were unable to profitably extract the zinc and there accumulated some ten to twelve million tons of mill residues, containing the major portion of the original zinc content. The invention of, or the application of the Potter, Delprat, Elmore, Cattermole and other methods, together with the mechanical variations and improvements which all of these flotation ideas have received, has enabled the accumulated zinc to be turned to profitable account. I may add that the great commercial prosperity of this district has been largely contributed to by the mechanical development of the long known flotation principle.

X Q. 35. You understand, do you not, that the testimony which

you are here giving for the defendant in this suit is being given voluntarily?

A. Yes, I came to give testimony entirely with the view to clear the charge which has been levelled at Mr. Hyde that he entered upon connection with the Butte and Superior Company as a result of information which he had obtained while in the employ of the
1784 Minerals Separation Company, which charge is not only untrue, but wicked.

X Q. 36. Are you testifying here with the knowledge and consent of the Board of Directors of Zinc Corporation?

By Mr. Scott: This question is objected to as incompetent, immaterial, and irrelevant, and having no bearing upon any issue of this case.

A. I am myself the managing director of the Zinc Corporation, I am violating no confidence in connection with that company's business. All the matters which I have stated are public property, and I am myself in any event entirely a free agent.

X Q. 37. You have not answered my question, which was whether or not you are testifying here with the knowledge and consent of the Board of Directors of Zinc Corporation. Please answer this directly.

By Mr. Scott: The objection last made is repeated.

A. The matter has never been before the Board of the Zinc Corporation, their approval has never been asked for.

X Q. 38. When was your attention first called to the affairs of the Butte and Superior Copper Company of Butte, Montana?

A. So far as my recollection goes, I never heard of the Butte and Superior Company in my life until I visited New York, in
1785 March, 1911, but as I stated before Mr. Beatty, with whom I am intimately associated in business, apparently had had some connection with this company some time previously.

X Q. 39. I take it that when the matter of the Butte and Superior Copper Company was called to your attention it appealed to you as providing an opportunity for an investment in the re-financing proposition; this is true, is it not?

A. It did.

X Q. 40. I take it also that the affairs of this company were then in such condition that financial aid had been called for?

A. I understood this company was desirous of raising further capital, and a proposal to take such an investment was put before me.

X Q. 41. Did you in any way, directly or indirectly, participate in the financial scheme which finally resulted in this matter?

A. I did not, because after leaving New York the parties interested seemed to have forgotten the arrangement they entered into with me.

X Q. 42. You have stated that Mr. Hyde reported to you his opinion of the Butte and Superior ore. What was that opinion?

A. I do not recollect the precise terms, but in substance it was

to the effect that this company's profits could be greatly improved by the application of flotation methods to their ore treatment.

X Q. 43. Have you assisted the defendant in the defence
1786 of this suit otherwise than by appearing here as a witness?

A. I have not. I do not know enough about the technical matters involved, nor do I have any desire to take sides in the main issues of this litigation.

X Q. 44. Had you not placed at his disposal certain documents that might be of assistance to him?

By Mr. Scott: Question objected to as irrelevant, incompetent and immaterial.

A. I have no recollection of having given him any documents since this action began.

X Q. 45. You supplied him with a typewritten copy of the record in the British suit of the British Ore Concentration Company and Elmore against Minerals Separation, Ltd., did you not?

By Mr. Scott: Objection repeated.

A. I did not myself supply such a document; on Mr. Hyde's request, I placed him in communication with a firm of solicitors in London, who obtained for him the information that he wished.

X Q. 46. Have you any interest, directly or indirectly, in the alleged invention disclosed in the patent to the defendant, No. 1,022,085?

A. I have not. Mr. Hyde offered to present me with an interest in his invention, and I told him that I would not accept an interest in any process, even as a gift.

X Q. 47. Is it, or is it not, a fact that the operations of the
1787 Zinc Corporation in Australia involve the re-treatment of concentrates?

A. We do re-treat a portion of our concentrates to extract the lead. There are no patents on it, and any one can use it that likes.

X Q. 48. And about how long has this retreatment practice been carried out by Zinc Corporation?

By Mr. Scott: The question is objected to as incompetent, irrelevant and immaterial, as having no tendency to prove or disprove any issue in this case.

A. We have been using retreatment methods ever since we first built our first Potter mill.

X Q. 49. And what have you done with the middlings from retreatment?

By Mr. Scott: Preceding objection repeated.

A. So far as I know, the middlings are returned to the mill circuit and treated over again.

X Q. 50. This you would consider as ordinary metallurgical practice, would you not?

By Mr. Scott: Objection repeated.

A. I presume that it has been found advantageous by our metallurgists. The matter, however, has been called into a good deal of question, as to its advantages or disadvantages.

X Q. 51. The question is, of course, whether or not it pays to treat the middlings over again?

By Mr. Scott: Same objection.

1788 A. It is. So far as I know, the question is not entirely settled as to whether it is advantageous or not.

X Q. 52. I have what purports to be Directors' Report and Statement of Accounts for the period ending 31st December, 1911, of the Zinc Corporation, Limited, containing what is entitled "Directors' Report," and which appears to have been signed Mr. F. A. Govett and yourself, as managing directors, and referring to an appended report of Mr. Theodore J. Hoover, and I find in this appended report the following statement, referring to work done with the vacuum machines stated to have been set aside:

"And that while the material treated by the former method was very amenable to that method, it was a selection of material of the simplest metallurgical character amongst the Company's holdings, and that the remaining material was of such a character that it could not have been treated profitably by the former process."

Is the statement which I have quoted true or not?

A. The statement is no doubt true, but possibly a little overdrawn, as the sense intended was probably that the balance of the material could not be treated at nearly so great a profit.

X Q. 53. One of the employments which the defendant entered into after leaving Minerals Separation was that of engineer for the Oroya Exploration Company; this is true, is it not?

1789 A. Yes, I am the managing director of that company.

X Q. 54. How would you describe his position in that company?

A. He acted as the engineer in London for that company, jointly with others, during the short time he remained in this country.

X Q. 55. Would you describe his position as that of consulting engineer?

A. I should consider that his business was such, although I do not know that he had any precise title.

X Q. 56. Have you read the record of the defendant in this suit?

A. I have not.

Cross examination closed.

Deposition closed.

H. C. HOOVER.

At the request of counsel for complainants the Commissioner marks for identification the document produced when X Q. 31 was asked of the witness, as "Zinc Corporation Table."

Adjourned to Friday, the 16th of August, 1912, at 2 o'clock in the afternoon, at the same place.

1790 London, August 17th, 1912.

Met pursuant to adjournment.
Present: Counsel as before.

A. Howard Higgins, a witness produced on behalf of defendant, having been duly cautioned and sworn, testifies as follows:

Direct examination.

By Mr. Scott:

Q. 1. What is your name, age, residence and occupation?
A. Arthur Howard Higgins; 31; "Estrella," Hale Lane, Mill Hill, London, N. W.; metallurgist.
Q. 2. When did you first become engaged in research relative to oil flotation processes?
A. In December, 1903.
Q. 3. At that time, I believe, you were occupied with the Cattermole process, in which the object is to separate the oiled particles by permitting them to settle or be precipitated?
A. Yes, and also with the Froment process.
Q. 4. What was the purpose or object of your investigation of the Cattermole process?
A. Chiefly making tests on ores to find the applicability of the process to them.
Q. 5. Was the Cattermole process owned by the people who engaged you at the time that you first took it up?
A. I do not know.
1791 Q. 6. At this time, I believe, you were engaged by Messrs. Sulman & Picard; is that correct?
A. I was.
Q. 7. And afterwards, I believe, you entered the employ of Minerals Separation, Ltd.?
A. That is so.
Q. 8. About how long were you occupied with the Cattermole process while in the employ of Messrs. Sulman & Picard before entering the employ of Minerals Separation, Ltd.?
A. About six months.
Q. 9. Can you remember approximately the date on which you entered the employ of Minerals Separation, Limited?
A. I cannot. When I was employed by Sulman & Picard, Mr. Ballot was there and approved the appointment. My work was in connection with Minerals Separation work entirely, so that the change of employment was nominal rather than actual.

Q. 10. In a general way, what was the nature of your first research or experiments in connection with the Cattermole process?

A. I was first instructed in the use of this process, and afterwards assisted Mr. Chapman in testing ores to find the applicability of the process to them.

Q. 11. With what sort of success was the Cattermole process applied to the ores upon which you experimented?

A. I remember several successes, and only one failure.

1792 Q. 12. Did you investigate the cause of failure in that instance?

A. The cause of the failure was due to the large amount of soluble carbonate contained in the ore.

Q. 13. And what effect did this soluble carbonate have?

A. It prevented granulation.

Q. 14. By granulation I presume you refer to the agglomerating or adhering together of small particles to form larger particles?

A. Not entirely. A granule is something more than an agglomerate, being a hard, more or less rounded mass, whereas an agglomerate is not necessarily rounded.

Q. 15. I presume the presence of carbonate incidentally has the effect of causing the consumption of a larger amount of acid than otherwise would have been the case?

A. Certainly.

Q. 16. But even when large amounts of acid were used, still the desired granulation did not take place?

A. Yes, that is so, by reason of the amorphous precipitates produced, absorbing oil in preference to the sulphides.

Q. 17. The amorphous precipitates of what?

A. Such bases as were present in the carbonate, calcium, manganese, and iron.

Q. 18. In what manner was the mixture of ore, water, oil and mineral acid agitated in these experiments?

1793 A. In what was commonly known as a gabbet mixer. A further agitation took place in a modified gabbet mixer, that is to say, the baffles were removed.

Q. 19. As I understand your answer, together with my information on this subject, in the Cattermole process a quite violent agitation was first used for the purpose of bringing the oil into intimate contact with the metalliferous particles, after which a more gentle agitation was used for the purpose of promoting granulation of the metalliferous particles; am I correct in this?

A. No, the violent agitation produced incipient granulation, and the more gentle agitation afterwards perfected the granulation. The size of the granules depends on the nature and duration of this second agitation.

Q. 20. At about what period of your engagement upon this work was this, what I may term two-stage agitation, adopted?

A. It was in use when I was instructed in the process by Messrs. Sulman & Picard.

Q. 21. And was this two-stage agitation adhered to in the subsequent practice of the Cattermole process?

A. It was.

Q. 22. Was it considered the best way of carrying out the Cattermole process?

A. Yes.

Q. 23. In the Cattermole process I presume different results were secured with different oils or fatty matter, or that different oils and fatty matter had to be used in different quantities or in a different way?

1794 A. Yes, different oils and mixtures of oils were used. I believe also in different ways and very slightly different quantities.

Q. 24. About what was the range of quantities of different oils found necessary and advantageous?

A. In general we used 5 per cent. of oil on the mineral, which was increased perhaps to six or seven per cent., and decreased to three or four per cent.

Q. 25. In order to make the record perfectly clear to any one not accustomed to this terminology, please state whether by the word mineral you refer to the entire body of ore being treated, or to the metalliferous constituents which it was desired to separate from the ore?

A. I refer to the metalliferous constituents.

Q. 26. Will you compare the degree or kind of agitation to which the mixture of ore, oil, water, and acid is subjected in the first part of the Cattermole process, with the agitation employed when it is desired to float the metalliferous constituents according to the operations referred to in United States patent 835,120, involved in this suit?

A. The degree of agitation in the Cattermole process is not quite so violent as that used in the process referred to in the patent in suit. if the results are to be expected in the same time. If you use the same degree of agitation the results in the process of the patent in suit require longer time for their production than is the case in the Cattermole process.

Q. 27. When did you first learn of the use of oils or fatty
1795 matter in connection with the flotation of part of the constituents of an ore?

A. As far as I remember, I was instructed in this by Messrs. Sulman & Picard about December, 1903, and January, 1904. This does not include the Elmore buoyancy process.

Q. 28. You had heard of the Elmore process at an earlier date?

A. I was instructed in the essentials of the Elmore process whilst at the Royal School of Mines.

Q. 29. You are a Fellow of the Royal School of Mines, are you not?

A. There is no Fellowship. I am an Associate of the Royal School of Mines.

Q. 30. What was the occasion of Messrs. Sulman & Picard instructing you in December, 1903, and January, 1904, in the use of oils or fatty matter for flotation of part of the constituents of an ore?

A. I believe it was simply to give me all the information they had on oil processes.

Q. 31. And what information did they impart to you at that time?

A. As far as I remember, it was an alternative to the Cattermole second agitation, and consisted in the use of gas or air, introduced or generated in the pulp containing the agglomerations or imperfectly granulated mineral, for the purpose of bringing this up to the surface as a scum.

Q. 32. Did you do any work along this line at that time?

1796 A. Not very much. I do not remember any specific tests.

Q. 33. Do you remember whether Messrs. Sulman & Picard's instructions were represented to you as ideas of their own, or of others?

A. At that time they were not identified.

Q. 34. During your research in connection with the Cattermole process were any of your efforts directed towards improving that process?

A. Not in actually improving the process, but in improving the application of it, I certainly tried some experiments.

Q. 35. Will you describe in a general way the form of apparatus which you used in first applying the Cattermole process?

A. This apparatus consisted of an ore-chute, feeding into a series of four gabbet mixers, followed by a spitzkasten with cylindrical sides. The pulp, after being agitated, in passing through these four gabbets, passed into the spitzkasten, where the separation of gangue slimes from the remainder was effected. The remainder passed into two succeeding gabbet mixers, running at lesser speed than the previous four, where the granulation was perfected. The pulp then passed into another cylindrical spitzkasten, where the gangue was washed away in the overflow, and the granules fell out in the underflow.

Q. 36. About what time was it that you entered the employ of Messrs. Sulman & Picard, that is, what year?

A. Towards the end of December, 1903.

1797 Q. 37. Did you find this apparatus which you have described in answer to question 35, constructed and in use at the time you were engaged by Messrs. Sulman & Picard, in December, 1903?

A. I did.

Q. 38. Were there baffles in the first set of four gabbets, and also in the second set of two gabbets referred to in your answer to question 35?

A. There were baffles in the first four mixers, but none in the last two, that is, the fifth and sixth mixers.

Q. 39. When did you first learn of the Froment process, which you have mentioned?

A. I think this was early in 1904.

Q. 40. And how did you learn of the Froment process, that is through whom, or by what means?

A. There were three pieces of apparatus lying about the laboratory, and I inquired of Mr. Chapman their use. He explained that these

were for carrying into effect the Froment process, and briefly explained the process.

Q. 41. Can you at this date give any description of this apparatus?

A. The first piece of this apparatus consisted of a cylindrical vessel, with a small hopper attached to the side of the vessel, the whole capable of holding ten litres or so of water. The vessel contained two stirrers, consisting of short horizontal arms carried on two elliptical frames. The latter could be rotated in opposite directions by means of gearing ending in a handle. The second piece of apparatus consisted of a cylindrical vessel, with a spout carrying at the
1798 bottom a double coiled lead pipe, with perforations. A rake was suspended in this vessel, so that the contents could be stirred. The third piece of apparatus consisted of a wooden box carrying an aluminum sieve and a cam and shaft for agitating the screen. Pipes in this wooden trough allowed the contents of the box to be drawn off at different places.

Q. 42. What sort of experiments did you perform in the way of improving the application of the Cattermole process as referred to by you in answer to question 34?

A. These were chiefly in the use of different oils in different emulsifications. That is all I remember at present.

Q. 43. Were the quantities of oil and acid to be used a subject of interest at that time?

A. I do not remember anything being said about the quantity of oil, except the quantity used was always adjusted to give granulation.

Q. 44. In adjusting the oil to give the best granulation, I presume you experimented with different quantities of oil?

A. Yes, there may have been different quantities, but whenever the granulation became imperfect by reason of the drop in the quantity of oil, the oil was naturally increased.

Q. 45. Did you perform any experiments in connection with the Froment process?

A. Yes one or two, I remember.

1799 Q. 46. What apparatus did you use in performing these experiments?

A. The Froment apparatus already described.

Q. 47. You do not remember performing any considerable number of experiments with this apparatus?

A. No, not a considerable number, the results in the few I have mentioned being hopeless.

Q. 48. And after performing these experiments was the Froment apparatus put aside?

A. It was.

Q. 49. Do you remember what finally became of it?

A. I cannot say where it was disposed. It is certainly not in the possession of Minerals Separation, Limited. I have made a search for it recently, and have not found any part.

Q. 50. It undoubtedly has been scrapped?

A. Yes.

Q. 51. Have you any recollection at all as to how long you saw this apparatus around the laboratory?

A. I certainly saw it in the beginning of 1906, but I have no recollection of having seen it since.

Q. 52. I presume you do not know by whose instructions it was destroyed or otherwise disposed of?

A. No, I do not know.

Q. 53. Do you know whether anyone else experimented with the Froment apparatus besides yourself?

A. I never saw anybody do so.

Q. 54. You would probably have seen them if they had experimented with it, would you not?

A. Certainly.

1800 Q. 55. By whose instructions, if any one's, did you experiment with the Froment apparatus?

A. These probably came to me through Mr. Chapman, from Messrs. Sulman & Picard.

Q. 56. You do not remember that Messrs. Sulman & Picard themselves personally gave you such instructions?

A. No, my memory is that Mr. Chapman gave me these instructions.

Q. 57. Do you remember whether you had a request or instructions from anyone to terminate your experiments with the Froment apparatus?

A. No, I remember no instructions to terminate this work. It is possible that it was interfered with by other work.

Q. 58. And it is quite probable, I presume, that you exercised your own judgment in the matter of proceeding with the Froment experiments?

A. No, I think I was working under Mr. Chapman's instructions.

Q. 59. What was the first occasion upon which you ever saw part of the constituents of an ore, which, in the form of a pulp, had been oiled, floating upon the surface of the pulp?

A. I cannot state the first occasion, as very small percentages of mineral frequently floated on the surface of the pulp contained in the spitzkasten during the operations with the Cattermole process. I do not think this proportion of mineral ever exceeded 5 per cent. of the whole.

1801 Q. 60. With what kinds of oil did you operate, when applying the Cattermole process?

A. Thick residuums, thinner residuums, or thick residuums thinned with lighting oil, oleic acid, and turpentine. That is all I remember.

Q. 61. The residuums you refer to are petroleum residuums, I presume?

A. Chiefly.

Q. 62. Are there any other residuums that you recollect using?

A. Yes, residuum from wood tar distillations.

Q. 63. What was the first occasion upon which you ever saw an oiled concentrate floating upon the surface of a pulp in the form of a scum or froth?

A. I do not understand this question. Do you mean the bulk of the concentrate floating as a scum or froth?

Q. 64. I mean a considerable proportion of it.

A. With the exception of the floating flocks already described, I saw this phenomenon for the first time whilst carrying out a series of experiments at the instructions of Messrs. Sulman, Picard and Ballot in the early part of March, 1905.

Q. 65. By which of these gentlemen were the instructions given to you?

A. By Mr. Sulman.

Q. 66. Can you state the nature of the instructions?

1802 A. These instructions were to carry out a series of tests on the factors influencing granulation.

Q. 67. And while performing these tests did you observe part of the metalliferous mineral floating as a froth or scum?

A. As far as I remember, in the bulk of these experiments there was a small quantity of floating mineral. This only reached appreciable proportions when the reduction of oil was carried down to very small proportions.

Q. 68. I presume the quantity of floating material increased gradually as the quantity of oil was reduced?

A. No, my impression is the quantity of floating material increased rapidly when the oil was reduced below a certain point.

Q. 69. And what was the certain point at which the rapid increase took place?

A. .62 per cent. of the oleic acid on the ore.

Q. 70. Is this report which you have referred to the original record that you made of your investigations, or was it preceded by some record made by yourself personally, and not typewritten?

A. This is the original record, made in my handwriting.

Q. 71. Then it was not preceded by any other memoranda on the subject?

A. It was preceded by no written report or memoranda. The facts contained in this report had been orally reported both to Messrs. Sulman and Picard and Mr. Ballot.

1803 Q. 72. You mean that prior to your oral report you had made no laboratory memorandum or notation whatever of the percentage of oil and of the result secured?

A. No, I do not mean that. I used to keep a rough record of the experiments, which never left my possession.

Q. 73. What did you do when you first tried your experiments with oil and reduced in quantity to .62 per cent. on the ore; I mean, did you immediately make your oral report that you had referred to to Messrs. Sulman, Picard and Ballot?

A. I called in Mr. Ballot to see one of these experiments performed, wherein froth was produced, but I cannot say which one it was. I may, therefore, have tried a further reduction of oil before making an oral report on it.

Q. 74. You recognized that the formation of this froth was not conducive to the granulation desired in the Cattermole processes, of course?

A. I recognized that this froth was different from the Cattermole

process, and could not, therefore, be considered either detrimental or advantageous to granulation.

Q. 75. Did you call in Messrs. Sulman, Picard and Ballot immediately or very soon after your experiment with the oil reduced to the neighborhood of .62 per cent.?

A. I cannot state the interval of time which elapsed between
1804 the performance of this experiment and the calling Mr. Ballot. It is possible that I made certain that this froth production was not accidental, and then called Mr. Ballot to see it.

Q. 76. Do you remember whether you noticed the appearance of the tailings when the froth was produced, for the purpose of forming an idea as to how complete a recovery was effected by the froth?

A. I feel certain I should do so.

Q. 77. And from the conditions of the tailings I presume you noticed that the recovery was quite high?

A. I did.

Q. 78. Did you before calling in Messrs. Sulman, Picard and Ballot remove any of the froth by spooning or skimming?

A. I should probably have removed some of this froth and examined it to judge its value.

Q. 79. What apparatus was used by you in your experiments in which you reduced the oil to the neighborhood of .62 per cent.?

A. I was using a single gabbet.

Q. 80. And when did the subject first come up of devising other apparatus for the purpose of continuing the investigation along the same lines?

A. I do not remember being consulted on this point.

Q. 81. What was the first apparatus that you saw designed especially for the purpose of separating the metalliferous mineral in the form of a froth?

A. I presume you mean the first apparatus for carrying out this process in a continuous manner. This consisted of a series of
1805 gabbet mixers for the agitation, and a compound spitzkasten, such as is described in the patent in suit, for the separation.

Q. 82. How did this apparatus, referred to in your last answer, compare in the production of a froth with the operation of the apparatus in which you first produced a froth?

A. The production was equally satisfactory. The separation of the froth, however, in the spitzkasten was not quite so complete as the apparent separation in the single gabbet on stopping the cone.

Q. 83. I do not quite follow the distinction you draw between the production of the froth and its separation. Will you kindly explain?

A. The froth is produced in the liquor during the agitation, and is naturally mixed with the gangue. The formation of froth is not evident except from an indication known as the "clean-up." This can, of course, be made evident by stopping the agitation, when the froth is allowed to separate from the gangue. The operation of separation I refer to is the actual act of separating the froth so formed from the remainder of the pulp.

Q. 84. And this act of separation, which I understand to be the

actual stratifying or separating of the froth and gangue into separate layers, is what you referred to as not being so satisfactory in the spitzkasten of the continuous machine as in the single gabbet with which you first experimented?

A. I did not refer to the actual stratifying, but rather to the separation of the different strata.

1806 Q. 85. And it was this separation of the different strata that was not quite so complete in the continuous apparatus as with the single gabbett with which you first experimented?

A. That is the meaning I intended to convey.

Q. 86. What took place in the spitzkasten of the continuous machine?

A. The pulp on reaching the water surface separated into a layer of froth which floated away over the discharge end of the spitzkasten. Owing to the fact that as the spitzkasten increased in width as it increased in length, a certain amount of expansion of the froth took place, which allowed some of the mineral contents to fall out. This obviously increased the mineral in the tailings. The tailings sank through the water and were drawn off at the points of the spitzkasten.

Q. 87. After this first continuous apparatus was built and operated, was another apparatus designed for continuous operation constructed?

A. I believe so. I left England for South America in the spring of 1906, and as far as I remember this apparatus was in use when I left. When I returned, about a year later, a different type of spitzkasten was in use.

Q. 88. In the first continuous-operation apparatus was the pulp discharged from the agitator through a pipe upon a shallow trough or apron, over which it flowed to the spitzkasten?

A. It was.

1807 Q. 89. Was this same arrangement present in the apparatus which you saw upon your return from South America?

A. So far as I remember, there was a launder also in that apparatus, carrying the pulp to the spitzkasten, which were rectangular or square, instead of increasing in width with length.

Q. 90. Do you remember any difference in the proportions of the apron or launder in the first continuous-operation apparatus and the proportions of the launder in the apparatus which you saw on your return from South America?

A. I have only an imperfect recollection of this plant. I saw it in operation on my return from South America, I believe previous to taking a short holiday, and I am under the impression that this plant was dismantled before I saw it on a second occasion.

Q. 91. After you had performed your experiments with the quantity of oil reduced to the neighborhood of .62 per cent. on the ore, and had noticed from the appearance of the tailings that the recovery in the froth was quite high, did it occur to you that a process of concentration might be carried out by separating this froth?

A. I was certain of it.

Q. 92. And did Messrs. Sulman, Picard and Ballot agree with you in that?

A. Undoubtedly. I remember Mr. Ballot was particularly enthusiastic.

Adjourned to Monday, the 19th of August, 1912, at 10:30 A. M., at the same place.

1808 London, August 19th, 1912.

Met pursuant to adjournment.

Present: Counsel as before.

Direct examination of Arthur Howard Higgins continued:

Q. 93. In operating the Cattermole process, did you employ the two-stage agitation both when the oil was directly added and when the oil was formed by the action of a mineral-acid upon soap, that is, formed in situ?

A. Yes.

Q. 94. About what length of time did each stage of the Cattermole agitation occupy?

A. The time varied as the state of crushing of the ore. In the plant already described, the first agitation, that is, the agitation given in the first four mixers, was supposed to occupy five to eight minutes, whilst the second agitation in the last two mixers, three or four minutes.

Q. 95. Was the instruction given you regarding the Froment process, and your trials of that process in the Froment apparatus, among the first things which occurred after your engagement by Messrs. Sulman & Picard upon the work of Minerals Separation, Ltd., late in December, 1903?

A. The instructions in the method of operating the Froment process, I think I had early in 1904. The tests I referred to were certainly in 1904, and, as far as I remember, a little later than the instructions.

1809 Q. 96. Is there any memorandum which you made and can refer to for the purpose of fixing the date when you made the tests with the Froment apparatus?

A. I fix these by the date of an incident.

Q. 97. My question was directed more particularly to ascertaining whether you can fix more definitely the date of your tests of the Froment apparatus?

A. I am confident that I had been instructed in the principles of the Froment process before the Minerals Separation laboratory was removed from Messrs. Sulman & Picard's, at 44 London Wall, to Aldermanbury avenue, whilst the tests I referred to were, in my recollection, carried out in the latter place.

Q. 98. I notice that the occupancy of the Aldermanbury avenue laboratory extended over a period of about a year, between the spring of 1904 and June, 1905. Can you not by some means fix the date of your tests of the Froment apparatus more definitely than

simply as having taken place during the occupancy of the Aldermanbury avenue laboratory?

A. As far as I remember, these tests were done in May or June, 1904.

Q. 99. Do you remember having made any formal or written report that would show the precise date when you tested the Froment process in the Froment apparatus?

A. No. At that time a good many failures were only reported orally.

Q. 100. Do you remember when you first learned that the Froment process was patented?

1810 A. I think in 1904, previous to the removal of the laboratory.

Q. 101. What kind of ore did you use in testing the Froment apparatus?

A. Copper ore containing gold and carrying probably 10 per cent. of soluble carbonates.

Q. 102. That is, the soluble carbonates occurred naturally in this ore?

A. Yes.

Q. 103. Where did this ore come from, that is, what mine or locality?

A. It is known as Nagyag. It came from either Austria or Hungary. Hungary, I believe.

Q. 104. Did you try any other ore by the Froment process in the Froment apparatus?

A. I do not remember any.

Q. 105. Did you try the Froment process, using any other apparatus than that sent to Minerals Separation by Mr. Froment?

A. Yes. I made experiments in test tubes, and in the gabbett.

Q. 106. What kind of oil did you use in operating the Froment process?

A. I think I tried the same oils as we used for the Cattermole process.

Q. 107. The same oils as are referred to by you in answer to question 60?

A. Yes.

Q. 108. Is lighting oil practically the same as what is often termed "kerosene"?

1811 A. Yes.

Q. 109. In your report, which has been marked for identification as "Higgins' Report, March 16, 1905," you state that a diminution of the percentage of oil when that oil is either paraffine or Balkhany crude oil does not cause a similar frothing to the oleic acid. Have you since found it possible to use other oils than oleic acid with the result of producing a froth?

A. Yes.

Q. 110. What other oils?

A. I have obtained satisfactory results by the use of petrol, certain portions of the distillate of crude petroleum, such as cosmos oil,

vegetable oils, such as palm oil, cottonseed oil, linseed oil, and animal oils, such as lard oil, and oil squeezed from beef fat.

Q. 111. Have you been successful in the use of eucalyptus oil?

A. Yes.

Q. 112. Is the petrol to which you refer the distillation product of petroleum, sometimes known as "gasolene"?

A. The petrol I refer to is one of the lightest constituents of crude petroleum. I do not know whether gasolene is the same material.

Q. 113. The petrol you refer to is the distillation product commonly used in internal combustion engines, such as automobile engines, is it not?

A. Yes, it is known as .680 spirit.

Q. 114. Is the "paraffine" referred to in Higgins' Report, March 16, 1905, the same as lighting oil or kerosene?

1812 A. Yes.

Q. 115. In using these different oils in the operations set forth in the patent in suit, do you find it necessary in treating the same ore to use different quantities of these oily substances?

A. Referred to the same ore, the quantity used is generally the same, but referred to different ores, the quantity may be different.

Q. 116. Do you mean that in treating the same ore you use the same quantities of all of the different oils referred to?

A. I mean the same results can be obtained by the use of the same quantity, but commercial consideration frequently causes one oil to be used in less quantity than another.

Q. 117. Can you state what the smallest quantity is of eucalyptus oil that will produce a froth, operating upon, say, some one of the Broken Hill ores with which you have experimented?

A. The smallest quantity of eucalyptus which I have found in my experiments on Broken Hill ore to give a satisfactory concentration as a froth, is half a pound to the ton of ore.

Q. 118. Would you obtain equally good results on that same ore using one-half pound of Cosmos oil?

A. Speaking from memory, I believe the results on Cosmos oil may have been a little lower when such a quantity of oil was used.

Q. 119. Will Cosmos oil in any quantity give as good a recovery as eucalyptus oil?

1813 A. Yes, I think so.

Q. 120. You would have to use more of the Cosmos oil than eucalyptus oil?

A. I am not certain that I should do so. I have not made comparative experiments with these two oils, and it is possible that the same results might be obtained in different periods of time for the agitation.

Q. 121. What is Cosmos oil, that is, what is its origin, and what is it used for?

A. It is a petroleum distillate, sold for lubricating purposes.

Q. 122. Is it what is sometimes called cylinder oil?

A. I do not know. I think it is more in the nature of a valve oil.

Q. 123. Is the Cosmos oil the Standard Oil Company's Cosmos oil?

A. Yes, the samples were obtained from their London firm, The Anglo-American Oil Company.

Q. 124. Of what oil can you use the smallest quantity in carrying out the operations of the patent in suit, and of what oil is it necessary to use the largest quantity, in your experience?

A. Generally, I should expect the least quantity of oil to be one of the thinnest of oils, and the biggest quantity a thick oil, that is, referring to the same time for the agitation.

Q. 125. Referring to the continuous-operation apparatus which you saw upon your return from South America, do you remember seeing any later continuous-operation apparatus constructed and operated after that one, that is, in London, I mean?

1814 A. Yes.

Q. 126. In what laboratory was the apparatus which you saw on your return from South America; that is, where was the laboratory located?

A. In Charlotte street.

Q. 127. Do you know why this particular apparatus was dismantled before you saw it a second time?

A. No, that was determined by Mr. Theodore J. Hoover.

Q. 128. Where and when did you see the next continuous-operation apparatus?

A. In the same building at a later date. I am not certain as to the date when this apparatus was actually installed, but I remember it was in running condition when I left for Australia in August, 1908.

Q. 129. In what respect was this apparatus different from the one you saw on your return from South America?

A. Chiefly in size.

Q. 130. Do you know whether the Nagyag ore is now being treated by a flotation process?

A. I do not.

Q. 131. You do not know that it is being so treated, or that it is not being so treated?

A. I do not know that it is being treated.

Q. 132. Did you ever experiment with flotation of the Nagyag ores other than in connection with the Froment process?

A. I do not remember having done so.

Q. 133. Have you any personal knowledge of Minerals
1815 Separation ever having successfully treated the Nagyag ores by the operations set forth in the patent in suit?

A. I have no personal knowledge of such operations.

Q. 134. Did the apparatus constructed after the one you saw on your return from South America differ from the preceding one in any other respects than size?

A. My recollection of the apparatus in use when I returned from South America is somewhat scanty, and I am therefore unable to compare it in detail with the later apparatus mentioned.

Q. 135. Can you describe the later apparatus, and if so, will you?

A. The apparatus consisted of a hopper to feed ore into a series of mixers, consisting of boxes about 14 or 15 inches square, and

about 3 feet deep. There were, I believe, seven of these. Water, oil, acid and steam could be fed into any one desired, and arrangements were made for drawing off the pulp from any one of them. The separating apparatus consisted of four spitzkasten, square in section, having an apron or launder, such as is shown in the patent in suit. There were filters and settling tanks for the concentrates and tailings, with pumps and pipes for the return of the liquor to a head tank.

Q. 136. What kind of apparatus did you see in Australia for carrying out flotation operations?

A. A series of mixers for the agitation, six in number, of
1816 which five were in general use. The ore was fed into these mixers from a hopper, in which water was added. Sulphuric acid and steam were fed into the first agitator box. Oleic acid was fed into the second box, and the agitation continued in these boxes until No. 5 was reached, where additional acid could be added if desired, before the discharge of the pulp into a launder. The launder delivered the pulp into a spitzkasten, where a considerable amount of thick froth was removed as an overflow, the remainder passing out as the underflow into a second launder, which carried the material to a second spitzkasten. Here more froth was removed as an overflow, and the tailings, or underflow, discharged into a launder carrying them to a third spitzkasten. There were two sections so described. The underflow from the third spitzkasten of both sections ran into a common sump, from which they were taken by an elevator to a fourth spitzkasten, from which the final froth was taken, the tailings passing to settling tanks. The combined concentrate ran into a settler, consisting of a large hopper, over which sprays of water were adjusted. These sprays of water caused the bulk of the froth to break up and so discharge the bulk of its contents. These were removed at the bottom of the hopper. The overflow, carrying some mineral and a good deal of gangue slime, passed at one time into a special sump, where a good deal of impure concentrate was collected. This impure concentrate was fed back to the plant at intervals. The liquor, after passing through this
1817 special sump, still contained some mineral and gangue slime, and passed to the pump sump, from which it was returned to the hopper, previously mentioned, in which water was added to the feed.

Q. 137. What ore were you using when you made your experiments for the purpose of ascertaining the effect of varying the quantity of oil upon granulation?

A. Broken Hill crude ore, obtained, as far as I know, from the Central mine.

Q. 138. What is the nature of your present duties for Minerals Separation, Limited?

A. Testing, or supervising testing, operations on samples of ores, to find the applicability of the different Minerals Separation processes to them; also experimental work in improving processes.

Direct examination closed.

Cross-examination.

By Mr. Williams:

X Q. 139. In Q. 66 you were asked as to the nature of instructions received by you, and in your answer to Q. 67 you speak of the reduction of oil being carried down to a very small proportion, and in Q. 137 this work, I take it, was referred to as experiments for ascertaining the effect of varying the quantity of oil upon granulation. Please state as accurately as you can what were these instructions, so far as they related to the quantity of oil.

A. As far as I remember, the instructions were to start with large quantities of oil, say the upper limit of Cattermole's specified quantity, and reduce this as far as possible. In other words, to find the lowest limit at which any result could be obtained by the
1818 use of oil.

X Q. 140. And how far, in fact, did you, in carrying out these instructions, reduce the quantity of oil?

A. 0.1 per cent. is the lowest quantity of oil I reported as having used, although the absolute vanishing point, where no oil was used at all, was tested.

X Q. 141. You have referred to some floating material appearing at times in your work on the Cattermole process prior to March, 1905. Was this deemed an advantage or a disadvantage in that process?

A. It was deemed such a disadvantage that I arranged a piece of apparatus on the plant, which I called an "air-trap," to separate these floating flocks from the pulp before entering the spitzkasten. The flocks so separated were passed to the fifth mixer, where they were destroyed.

X Q. 142. Your answer to Q. 60 is not quite clear to me in its reference to oleic acid. Please explain a little more fully what use was made of oleic acid in the Cattermole process.

A. Oleic acid was used as soap, that is, its sodium or potassium salts, in forming the emulsions used in the Cattermole process; also as an oil emulsified with soap, and later as a solution of soap. In addition, it was also used as oleic acid itself, without emulsification or solution as soap.

X Q. 143. In your Report of March 2, 1905, in the first paragraph thereof, you speak of other conditions which suggested to you their importance in altering the time of granulation. What, if you remember, were these other conditions?

1819 A. I believe one of these conditions referred to the relation between the size of the cone, and the mixer or jar forming the gabbett. I think the others were of little importance, as far as I remember. One was the use of insoluble soaps in granulation.

X Q. 144. About what was the mineral-content, that is, the metalliferous mineral-content, of the Broken Hill ore which you were using in these tests wherein froth production first appeared?

A. The mineral content formed roughly 50 per cent. of the ore.

X Q. 145. After the froth had been produced in the single gabbett, what was done to remove it or separate it?

A. Mr. Ballot desired to know the weight of the froth and requested me to remove it by introducing a long-stemmed funnel and by pouring water down the funnel, causing the froth to overflow the top of the gabbett into a basin placed beneath. Experiments were also made in scooping this out with a spoon, and later the pulp was discharged onto a spitzkasten. At an early date Mr. Sulman brought an apparatus that he had had constructed, consisting of a septum passing through the vessel, which could be drawn through when the froth had been formed, and thus remove the froth bodily.

X Q. 146. In your answer to Q. 17 you refer to certain bases. What minerals were you referring to in that answer?

A. Calcium, manganese and iron are members of an isomorphous group of minerals, any one of which can replace in any quan-
1820 tity any of the others. I was referring to such minerals as would be commonly called "calcite," but which contain iron or manganese, so replacing the calcium in small quantities. These might be termed ferriferous or manganiferous calcite.

Cross-examination closed.

Deposition closed.

London, August 22nd, 1912.

Met pursuant to adjournment.
Present: Counsel as before.

The Commissioner notes that the letters or reports of Sulman & Picard to John Ballot, dated July 14, 1903; July 27, 1903, and August 11, 1903, were produced upon request of counsel for defendant, and submitted to him for examination, and returned by him.

The Commissioner also notes that all of the documents marked for identification were handed to defendant and his counsel for examination, and copies thereof supplied, as requested.

The defendant closes his case.

1821

Defendant's Exhibit Extract from "Treatise on Chemistry Applied to the Manufacture of Soap and Candles."

FLOTANT SOAPS.

Under this title are designated those soaps which, when in a state of paste, are batted or inflated with air, by which means its buoyancy becomes such, that the soap floats in the water. It is a favorite soap, not only on account of whiteness and mildness, but the facility with which it gives a lather. These soaps are colored and perfumed exactly as are the toilet soaps generally. It must be remarked, however, that the olive, palm, and sweet almond oil soaps are the only ones that can be converted into flotant soaps, it being impossible to inflate those soaps made of suet or lard. They are prepared from either of the preceding soaps, by cutting it into thin shavings and melting over a water-bath, with twelve pounds of water to every fifty pounds of soap. When the mass is in perfect fusion, it is agitated with a twirling fan (Figs. 54, 55), until it froths and foams to the top of the vessel.

Fig. 54.

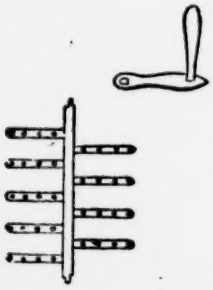


Fig. 55.

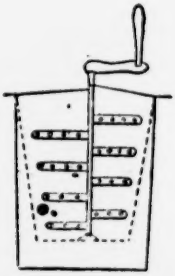
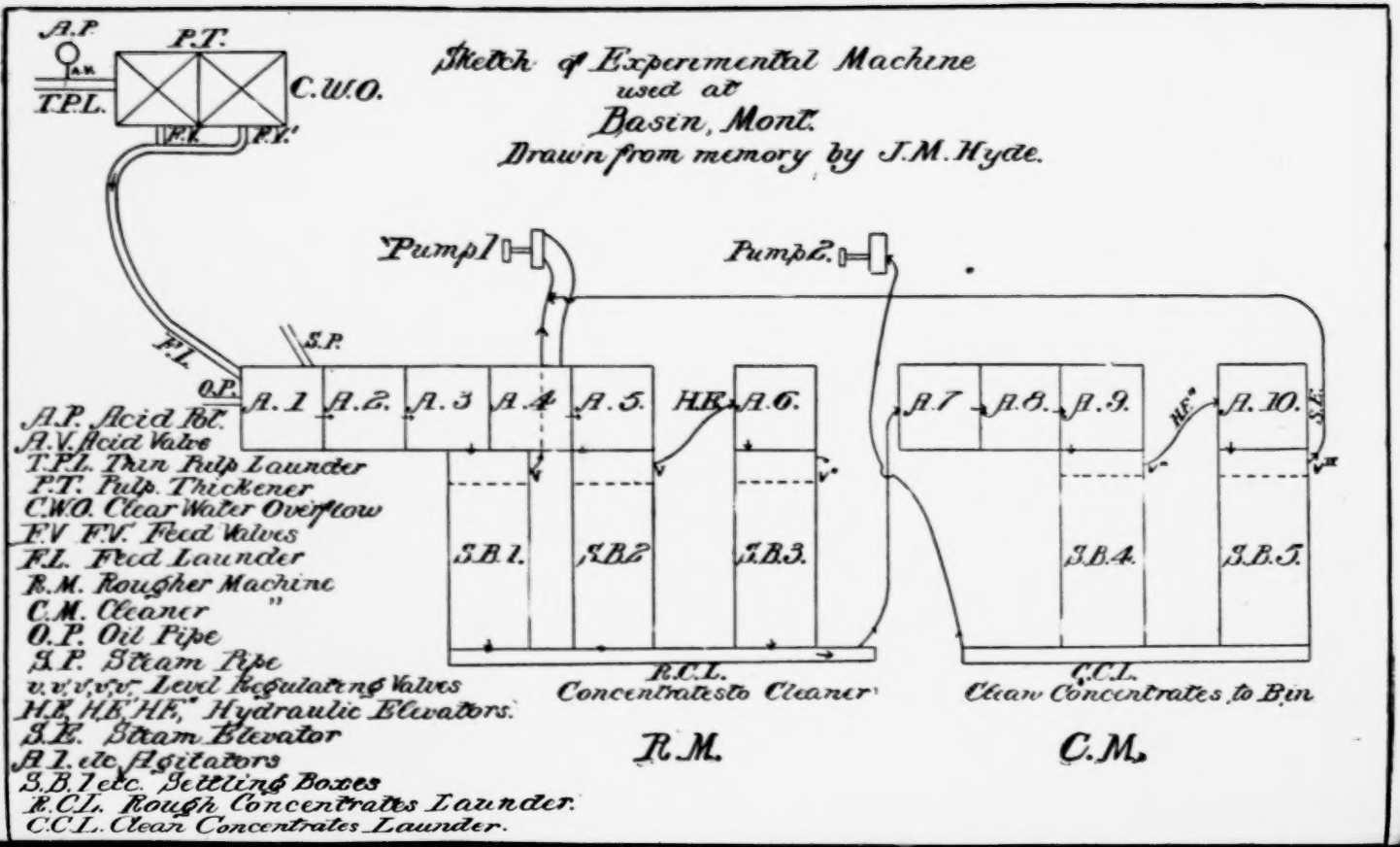


Fig. 54 represents the twirling fan detached from the water bath; it is made to revolve on a pivot, and to be taken on or off at will. After the perfume has been added, the contents are emptied out into cooling frames or moulds.

Defendant's Exhibit Hyde Sketch of Experimental Machine.



1823 DEFENDANT'S EXHIBIT.

Certified Copy of File-wrapper and Contents of Cattermole, Sulman & Kirkpatrick-Picard Patent No. 788,247.

United States of America,

Department of the Interior.

United States Patent Office.

To all to whom these presents shall come, Greeting:

This is to certify that the annexed is a true copy from the Records of this Office of the File Wrapper and Contents, in the matter of the Letters Patent of Arthur Edward Cattermole, Henry Livingstone Sulman, and Hugh Fitzalis Kirkpatrick-Picard, Number 788,247, granted April 25, 1905, for Improvement in Ore Concentration.

In testimony whereof I have hereunto set my hand and caused the seal of the Patent Office to be affixed at the City of Washington, this 31st day of January, in the year of our Lord one thousand nine hundred and twelve and of the Independence of the United States of America the one hundred and thirty-sixth.

[SEAL.] F. A. TENANT,
Assistant Commissioner of Patents.

1824 2–437.

Case A.

Number (Series of 1900).
200,649.

1904.

Divn. XXV.
Div. 25.
(Exr.'s Book) 8-134.

Patent No. 788,247.

Name: Arthur Edward Cattermole, Henry Livingstone Sulman and Hugh Fitzalis Kirkpatrick-Picard, of London.
County of ——, England.
Invention: Ore Concentration.

		Original.	Renewed.
Parts of application filed.	Petition,	Mch. 29, 1904,	—— —, 190-.
	Affidavit,	" " 1904,	—— —, 190-.
	Specification	" " 1904,	—— —, 190-.
	Drawing not required,	—— —, 190–,	—— —, 190-.
	Model or Specimen not required,	—— —, 190–,	—— —, 190-.
	First Fee, Cash $15,	Mch. 29, 1904,	—— —, 190-.
	I. " " Cert.	—— —, 190–,	—— —, 190-.
	Appl. filed complete	Mar. 29, 1904,	—— —, 190-.
Examined, Lewis B. Wynne,		Feby. 3d, 1905,	—— —, 190-.
Countersigned, J. W. Babson,		—— —, ——,	—— —, 190-.
		For Commissioner.	For Commissioner.
Notice of Allowance,		Feb. 6, 1905,	—— —, 190-.
Final Fee, Cash $20,		Apr. 5, 1905,	—— —, 190-.
" " Cert.,		—— —, 190–,	—— —, 190-.
Patented, April 25, 1905.			
Associate Attorney, —— ——.		Attorney-, Knight Bros.,	
2.			City.
Name, —— ——.		Serial Number, ——.	
Patent No. ——.		Date of Patent, ——.	

[On left margin:] Division of App. No. —, filed —— —, 190-.

1825 Serial No. 200,649, Paper No. 1½.

$15.00 Received Mar. 29, 1904. S. Chief Clerk, U. S. Patent Office.

Joint Petition.

Application.

To the Commissioner of Patents:

Your Petitioners Arthur Edward Cattermole, Henry Livingstone Sulman and Hugh Fitzalis Kirkpatrick-Picard, subjects of the King of England, and residents of London in England whose Post Office addresses are respectively 10 Woodland Rise, Highgate, London, England, and 44 London Wall, in the City of London, England, pray that Letters patent may be granted to them, as joint inventors, for the "Improvements in [or Relating to]* Ore Concentration" set forth in the annexed Specification, and they hereby appoint Knight Bros. of Washington, D. C., a firm consisting of Hervey S. Knight and Harry A. Knight their Attorneys with full power of substitution and revocation, to prosecute this application, to make alterations and amendments

Aug. 9/04.

[*Words and figures enclosed in brackets erased in copy.]

therein, to receive the Patent, and to transact all business in the Patent Office connected therewith.

Signed at London England this 16th day of March 1904.

Full names of Inventors:

ARTHUR EDWARD CATTERMOLE.
HENRY LIVINGSTONE SULMAN.
HUGH FITZALIS KIRKPATRICK-PICARD.

1826 To all whom it may concern:

Be it known that we Arthur Edward Cattermole, Henry Livingston Sulman and Hugh Fitzalis Kirkpatrick-Picard, subjects of the King of England, residing at London, England, have
Aug. 9/04. invented certain new and useful "Improvements in [or Relating to]* Ore Concentration" of which the following is a specification:

Our process has for its object the separation of minerals from the siliceous or earthy matters of ores by means of soaps or similar compounds, and is dependent upon the superior physical attraction exhibited by minerals for fatty or resin acids, or for certain other aromatic derivatives (such as cresols, phenols, etc.) which form soluble salts or compounds with alkaline hydrates, as compared with earthy or siliceous substances.

Insert A. Aug. 9/04.

In general the soluble compounds we employ are typified by ordinary soaps, from which the fatty or resin acids are liberated by the addition of a suitable mineral acid, and which fatty or resin acids are again rendered completely soluble by the addition of an equivalent of caustic alkali.

In carrying out our invention the suitably crushed ore is suspended in water, and to the mixture an addition of a small quantity of soap solution is made. A small amount of mineral acid is then added, which decomposes the soluble soap or other similar compound by uniting with the alkaline base thereof, thus liberating in
1827 a state of chemical sub-division the fatty or resin acid or other compound such as cresol, etc., in intimate contact with the suspended ore particles. It is found that the liberated acids, etc., which may even be solid under ordinary conditions, are precipitated and adhere to the sulphuretted minerals, or to sulphur, graphite, or free metals present in the ore, leaving the gangue or earthy particles preferentially wetted by water, and free from adhesions of fatty acid and the like.

The fatty acid and the like used for the purpose of adhering to the mineral particles is thus produced in situ throughout the suspended ore mass in the most intimate contact or admixture therewith.

The mineral particles now attached to, or more or less coated or enclosed by, films of fatty or resin acids and the like, are capable of

[*Words and figures enclosed in brackets erased in copy.]

being separated from the gangue or earthy particles by various methods dependent upon this altered physical condition.

For example, the coated mineral particles may be removed by generating gaseous bubbles in the mixture which preferentially attach themselves to the fatty or similar acid-coated particles and raise them to the surface of the pulp, whence they may be removed by skimming or the like. If the ore contain a carbonate, any small excess of the acid used to decompose the soap or similar alkaline compound will also liberate bubbles of carbonic acid, which will attach themselves to the fatty acid coated mineral particles, and float them to the surface; or a suitable carbonate (or other substance capable of liberating a gas on the addition of a suitable acid, such as an
1828 easily decomposable sulphide, etc.,) may be initially added to the ore mass for such purpose.

Or the mineral particles may be caused to adhere to metallic or other suitable surfaces coated with similar fatty acids; or, finally, the coated mineral particles may be caused to adhere to wood, sawdust, or other suitable material lighter than water, coated with similar fatty acids, etc., which can then be removed by flotation; in each case leaving the mineral-free gangue particles capable of rejection.

After separation of the coated mineral particles by any of the methods before mentioned, the recovered mineral concentrate is subjected to the action of a suitable amount of caustic or carbonated alkali, whereby the fatty or resin acid, etc., recombines completely with the alkali, forming a readily soluble soap or alkaline compound; after draining this off, and washing with water, if necessary, the mineral particles are left clean and free from soap.

The resulting solution thus contains all the soap or equivalent compound originally used, in a state ready for immediate employment in the separation of mineral from fresh quantities of ore; and the process becomes completely cyclic with regard to the soap employed.

Throughout the operation the same soap or similar compound is used, the constituent whereof may be quite solid under ordinary conditions, the only additions required being small quantities of mineral acid and alkali for the decomposition and re-composition of
1829 this agent during the cycle of operation.

What we claim as our invention and desire to secure by Letters Patent is:

Sub. A[1], Aug. 9/04.

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1. The herein described process of concentrating ores which consists in mixing the ore pulp with a soap solution and a mineral acid which liberates the organic acid from the soap, and thereafter separating the coated mineral matter from the non-coated gangue.

[Matter enclosed between rules erased in copy.]

2. The herein described process of concentrating ores which consists in mixing the ore pulp with a soap solution and a mineral acid

which liberates the organic acid from the soap, separating the coated mineral matter from the non-coated gangue and adding alkali to the coated mineral matter to reproduce the soluble soap.

Sub. A^c, Aug. 9/04.

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3. The herein described process of concentrating ores which consists in mixing the ore pulp with a soap solution and a mineral acid which liberates the organic acid from the soap, bringing the liquor into intimate contact with a gas and separating out the coated mineral matter which floats.

[Matter enclosed between rules erased in copy.]

4. The herein described process of concentrating ores which consists in mixing the ore pulp with a soap solution and a mineral acid which liberates the organic acid from the soap, bringing the liquor into intimate contact with a gas, separating out the coated
1830 mineral matter which floats and adding thereto an alkali which reproduces the soluble soap.

In testimony whereof we have signed our names to this Specification in the presence of two subscribing witnesses..

Full names of Inventors:

ARTHUR EDWARD CATTERMOLE.
HENRY LIVINGSTONE SULMAN.
HUGH FITZALIS KIRKPATRICK-PICARD.

2 Witnesses.

F. B. BUSS.
FREDERICK READ.

Oath.

LONDON,
England, ss:

Arthur Edward Cattermole, Henry Livingstone Sulman and Hugh Fitzalis Kirkpatrick-Picard the above named petitioners, being duly sworn, depose and say that they are subjects of the King of England and residents of London, in England; and that they verily believe themselves to be the original, first, and joint inventors of the "Improvements in or Relating to Ore Concentration" described and claimed in the annexed Specification; that they do not know and do not believe that the same was ever known or used before their invention or discovery thereof; or patented or described in any printed publication in any country before their invention or discovery thereof, or more than two years prior to this application; or patented in any country foreign to the United States on an application
1831 filed more than twelve months before this application; or in public use or on sale in the United States for more than two

years prior to this application; and that no application for patent on said improvements has been filed by them or their representatives or assigns in any country foreign to the United States, except as follows: Great Britain No. 17109, dated 6th August, 1903.

ARTHUR EDWARD CATTERMOLE.
HENRY LIVINGSTONE SULMAN.
HUGH FITZALIS KIRKPATRICK-PICARD.

[Revenue Stamp.]

Sworn to and subscribed before me this 16 day of March, 1904 by all three Deponents.

[NOTARIAL SEAL.] G. F. WARREN,
Notary Public.

Consulate-General of the United States of America for Great Britain & Ireland at London.

I, Richard Westacott Acting Consul-General of the United States of America at London, England do hereby make known and certify to all whom it may concern that George Frederick Warren who hath signed the annexed Certificate, is a Notary Public, duly admitted and sworn and practising in the city of London, aforesaid, and that to all acts by him so done full faith and credit are and ought to be given it Judicature and thereout.

1832 In Testimony Whereof, I have hereunto set my hand and affixed my Seal of Office at London aforesaid, this 18th day of March in the year of our Lord One Thousand Nine Hundred and Four.

[CONSULAR SEAL.] RICHARD WESTACOTT,
Acting Consul-General.

2-260.

M. E. C.

Div. 25, Room 15.

Address only "The Commissioner of Patents, Washington, D. C."

Paper No. 1.

All communications respecting this application should give the serial number, date of filing, and title of invention.

Department of the Interior,

United States Patent Office,

Washington, D. C., April 29, 1904.
Mailed " " "

Cattermole et al., care Knight Bros., Washington, D. C.:

Please find below a communication from the Examiner in charge of your application, #200,649, filed March 29, 1904, for Ore Concentration.

F. I. ALLEN,
Commissioner of Patents.

1833 It is suggested that "or relating to" be canceled from the title as surplusage.

The 1st claim is rejected in view of 228,004, Tunbridge, May 25, 1880, Washers, H. See line 45 of Tunbridge's specification.

Claim 2 appears to express novel subject matter. There is not, however, a proper line of division between the claims of this application and those of applicant's companion case, serial number 200,650. This companion case is so closely related to this that applicants will be required to insert a cross reference thereto, giving serial number and filing date.

Claim 3 is rejected in view of Tunbridge, cited, and e. g., British patent 12,778, Lake, June 4, 1902, Washers, H.

Claim 4 appears allowable.

LEWIS B. WYNNE,
Examiner, Division XXV.

T. F. MITCHELL.

1834 Serial No. 200,649, Paper No. 2.

Filed —— —, 190–.

Aug. 9, 1904,
Application Room,
U. S. Patent Office.

Aug. 10, 1904,
Patent Office,
Division XXV.

Room No. 315.

Amendment.

Inventors: Arthur Edward Cattermole, Henry Livingstone Sulman, Hugh Fitzalis Kirkpatrick Picard. Invention: Ore Concentration. Filed March 29, 1904. Serial No. 200,649.

Hon. Commissioner of Patents.

SIR: The above named application is hereby amended as follows:

Cancel the words "or relating to" from the title.

Page 1, at the end of the second paragraph insert:

A. *The process described in this application relates to a process somewhat similar to the process described and claimed in a copending application filed by us of even date with this application and serially numbered* 200,650.

Cancel claims 1 and 3 and substitute the following:

1835 Sub. B, Dec. 31/04.

A^1. 1. The herein described process of concentrating ores which consists in mixing the ore pulp with a soap solution and a mineral acid so as to liberate from the soap the organic acid which coats the desired mineral particles and not the gangue, and thereafter separating the coated mineral matter from the non-coated gangue.

[Matter enclosed between rules erased in copy.]

Sub. B^1, Dec. 31/04.

A^2. 3. The herein described process of concentrating ores which consists in mixing the ore pulp with a soap solution and a mineral acid so as to liberate from the soap the organic acid which coats the desired mineral particles but not the gangue bringing the liquor into intimate contact with the gas and separating out the coated mineral matter which floats.

[Matter enclosed between rules erased in copy.]

Remarks.

Tunbridge's process is not for ore concentration but for collecting metals suspended in waste waters. Tunbridge does not propose to separate minerals from ores and does not describe any method for doing so.

Applicants' process on the contrary is one by which metalliferous matter is separated out from the gangue with which it is associated in ores.

Tunbridge has not discovered that fatty acids have a preferential affinity for metalliferous matter over gangue and his process does not in any way depend upon such preferential affinity.

The Applicants have discovered that such fatty acids adhere to metalliferous matter, sulphuretted minerals, sulphur, graphite, or free metals leaving the gangue preferentially wetted by water
1836 and free from adhesions of fatty acid and the like; and their invention consists in liberating throughout an ore pulp a fatty or resin acid in such a state of chemical subdivision in intimate contact with the suspended ore particles so that the preferential affinity can be exercised.

Tunbridge deals with waste waters containing say gold in suspension. He captures that gold by forming in the water a coagulum which retains all the solid matter in suspension. It is to be noticed that this coagulum would collect solid matter quite irrespective of its nature and if Tunbridge's process were applied to an ore pulp both the metalliferous matter and gangue would be enclosed in the curd or coagulum and no separation would be effected.

In the Applicants' process on the other hand the whole object is separation, and the liberated fatty acid does not form a coagulum and does not adhere to the gangue but merely forms a thin coating on the particles of metalliferous matter and the like enabling these particles to be separated from the gangue or earthly particles by various methods depending on its altered physical condition as by flotation by gaseous bubbles.

Tunbridge forms his coagulum in the soapy water by either using hard water or by adding some substance, preferably sulphate of lime to cause the soap to form a curd. Even supposing some fatty acid were liberated in Tunbridge's process it would all be included in the curd and could not exercise a preferential affinity.

1837 The Applicants' object is not to make a curd and they do not use sulphate of lime. Their object is first to liberate the fatty acid and afterwards to saponify it again.

It is respectfully submitted that Tunbridge's specification does not in any way suggest the Applicants' method of separating metalliferous matter from gangue by the preferential affinity of fatty acids.

Lake (Froment) British Patent No. 12778/03.

This specification discloses the use of a gas to separate "oily" metalliferous matter from gangue by flotation but Froment has not recognized the selective power of fatty or resin acids and he has not discovered that the acid liberated from soap or the like will first coat the metalliferous particles in preference to gangue and will enable the particles to adhere to gaseous bubbles and be separated by flotation.

The Applicants do not attempt to claim the flotation process broadly, but claim 3 is for the combination of the fatty acid selection with the separation by flotation.

Respectfully submitted, KNIGHT BROS., *Attorneys.*

Washington, D. C. August 5, 1904.

1838 M. E. C.

2–260.

Div. 25, Room 15.

Address only "The Commissioner of Patents, Washington, D. C."

Paper No. 3.

All communications respecting this application should give the serial number, date of filing, and title of invention.

Department of the Interior,

United States Patent Office,

Washington, D. C., October 4, 1904.
Mailed " " "

Cattermole, Sulman and Kirkpatrick-Picard, care Knight Bros., City:

Please find below a communication from the Examiner in charge of your application, #200,649 filed March 29, 1904, for Ore Concentration.

F. I. ALLEN,
Commissioner of Patents.

Case as amended and argued August 9, 1904, further considered.

The only distinction of process in the first claim as relates to the prior art (575,669, Robson, Jan. 9, 1897, Washers, H) lies in the particular reagent employed for coating the metallic particles, and perhaps in the particular method of forming the reagent.

1839 Applicant employs the organic acid from soaps. Now, it is old to employ such acids—see the "red oil" referred to in line 84, page 1 of 348,157, Everson, August 24, 1886, Washers, H, and it would not be a matter of invention to employ such oils obtained from soap, especially as Everson mixes her oils, including glycerides, (tallow, lard oil, etc.—which should release the acid on reaction with mineral acids)—with mineral acids, before separation. In view of this, the 1st claim is rejected as destitute of patentable novelty. See also 689,070, Elmore, Dec. 17, 1901, Washers, H.

The 3rd claim is rejected in view of the references for claim 1, and Lake, of record. Lake discloses the process excepting only as to the particular oil employed and Everson discloses the use of fatty acids. This claim should be made more specific.

The 2nd and 4th claims may possibly be allowed.

A. McNAUGHT,
Act'n Examiner, Division XXV.

T. F. MITCHELL.

1840 Serial No. 200,649, Paper No. 4.

Application Room,
Dec. 31, 1904,
U. S. Patent Office.

Patent Office,
Jan. 3, 1905,
Division XXV.

Room No. 315.

Amendment.

Inventors: Cattermole, Sulman & Picard. Invention: Ore Concentration. Filed March 29, 1904. Serial No. 200,649.

Hon. Commissioner of Patents.

SIR: The above-named application is hereby amended as follows:

Cancel claims 1 and 3 and insert:

68—Rec.

B. 1. The herein described process of concentrating ores which consists in mixing a freely flowing ore pulp with a soap solution and a mineral acid so as to liberate the organic acid from the soap throughout the suspended ore mass in intimate contact therewith, whereby the organic acid coats the desired mineral particles and not the gangue, and thereafter separating the coated mineral matter from the non-coated gangue.

B¹. 3. The herein described process of concentrating ores which consists in mixing a freely flowing ore pulp with a soap solution and a mineral acid so as to liberate the organic acid from the soap throughout the suspended ore mass in intimate contact therewith, bringing the liquor into intimate contact with a gas which will adhere to the coated particles and separating out the coated mineral matter which floats.

1841 *Remarks.*

The Examiner suggests that the only distinction of process in the first claim over Robson No. 575,669, is in the particular re-agent and its method of formation; and again that Everson by suggesting the use of "red oil" has anticipated the Applicants. But it is to be noticed that these cited processes are really of entirely different type from that of the applicants.

Robson takes a plastic mass of ore, "avoiding as far as possible the presence of water"; he forces an oily liquid up through the mass and washes away the metallic matter in a stream of oil. Everson mixes the powdered ore with the oily substance so as to produce a stiff mass after the minerals have been incorporated, and thereafter the gangue is washed out of the pasty mass by water. The real secret of successful separation is this, that each particle of mineral must be brought into intimate contact with the material used for separation. This cannot be done in a pasty mass. Applicants have discovered that when a soap solution is mixed with a freely flowing pulp and a mineral acid is added, the fatty acid is liberated throughout the suspended ore mass in the most intimate contact therewith, and thereby each mineral particle becomes coated or enclosed by a thin film of fatty or resin acid. Everson requires many times the quantity of oil that the applicants do, and the process as described by her is not commercially possible.

1842 It is therefore respectfully submitted that Claim 1 in its amended form clearly distinguishes the invention from the prior art.

With regard to claim 3 the applicants admit that Froment has discovered a process of gaseous flotation as applied to oil concentration and they have no desire to make a claim for such a process, but Froment was not aware of the advantages arising from the use of fatty or resin acid liberated from soaps and Froment could not have foreseen that the acid from a soap would form such a film on mineral particles that gaseous bubbles or the like would adhere to the particles and cause them to float. Moreover it is submitted that Claim 3, particularly in its amended form covers a novel combina-

tion of steps which constitutes a process which is accompanied by considerable utility.

Everson's U. S. Patent 348,157.

The powdered ore is mixed with an oily substance so as to produce a stiff mass after the materials have been incorporated and thereafter the gangue is washed out of the pasty mass by water. There is no suggestion here of the use of soap or the alternate formation of fatty acid and re-formation of soap.

Everson was ignorant of the chemical facts involved and states that in the case of petroleum or paraffine there is a compound produced between the mineral, water, acid and oil in the concentrates and infers a combination between dilute acid and paraffine. This is untrue; the action of concentration is purely a physical one.

A very important line of distinction between Everson's
1843 process and the Applicants' is that Everson oils the whole of the *ore and gangue* initially as thoroughly as possible and seeks to wash the gangue out of the mass by acid water or the like. The Applicants on the other hand avoid any oiling of the gangue by wetting the whole first with water and by such preferential wetting and the modes of producing the oleic acid *only the metalliferous matter present is coated.* The Applicants never make a pasty mass of the whole ore but only seek to coat every particle of metalliferous matter as thinly and evenly as possible and therefore to keep the gangue and the mineral particles from agglomerating together.

It is absolutely essential to the success of the Applicants' process that the fatty substance (oleic acid say) must be in the extremest sub-division and must make an intimate contact with the mineral, and the same uniform quantity with regard to any mineral particle, however small this ratio may be. This uniformity cannot be obtained by simply pouring oleic acid into the pulp. The only way of obtaining the small uniform layers of oleic acid on the individual particles is to add a soap solution which permeates the pulp completely, and then decomposing this in situ, i. e., in actual contact with the individual particles.

Respectfully submitted,

KNIGHT BROS., *Attorneys.*

Washington, D. C., December 31, 1904.

H.

1844

2-181.

A. R.

Issue Division.

Serial No. 200,649.

All communications should be addressed to "The Commissioner of Patents, Washington, D. C."

Department of the Interior,

U. S. Patent Office,

Washington, D. C., Feb. 6, 1905, *190–*.

Arthur E. Cattermole, Henry L. Sulman and Hugh F. Kirkpatrick-Picard, c/o Knight Bros., City.

SIR: Your application for a patent for an Improvement in Ore Concentration. Filed March 29, 1904, *1*—, has been examined and allowed.

The final fee, Twenty Dollars, must be paid, and the Letters Patent bear date as of a day not later than six months from the time of this present notice of allowance.

If the final fee is not paid within that period the patent will be withheld, and your only relief will be by a renewal of the application, with additional fees, under the provisions of Section 4897, Revised Statutes. The Office aims to deliver patents upon the day of their date, and on which their term begins to run; but to do this properly applicants will be expected to pay their final fees at least twenty days prior to the conclusion of the six months allowed them by law. The printing, photolithographing, and engrossing of the several patent parts, preparatory to final signing and sealing, will consume
1845 the intervening time, and such work will not be done until after payment of the necessary fees.

When you send the final fee you will also send, distinctly and plainly written, the name of the inventor and title of invention as above given, date of allowance (which is the date of this circular), date of filing, and, if assigned, the names of the assignees.

If you desire to have the patent issue to assignees, an assignment containing a request to that effect, together with the fee for recording the same, must be filed in this Office on or before the date of payment of final fee.

After issue of the patent uncertified copies of the drawings and specifications may be purchased at the price of 5 cents each. The money should accompany the order. Postage stamps will not be received.

Respectfully,

F. I. ALLEN,
Commissioner of Patents.

After allowance, and prior to payment of the final fee, applicants should carefully scrutinize the description to see that their statements and language are correct, as mistakes not incurred through the fault of the office, and not affording legal grounds for reissues, will not be corrected after the delivery of the letters patent to the patentee or his agent.

In remitting the final fee give the Serial Number at the head of this notice.

If payment is made by check or draft, the credit allowed is subject to the collection of the same.

1846 2–327.

√$20 Received Apr. 5, 1905. Y. Chief Clerk, U. S. Patent Office.

Memorandum of Fee Paid at United States Patent Office.

(Be careful to give correct Serial No.)
Serial No. 200,649. —— —, 190–.
Inventor-: Arthur E. Cattermole, Henry L. Sulman & H. F. K. Picard.
Patent to be issued to —— ——.
Name of invention, as allowed: Ore Concentration.
Date of Payment: April 5, '05.
Fee: $20.
Date of Filing: Mar. 20, '04.
Date of Circular of Allowance: Feb. 6, '05.
The Commissioner of Patents will please apply the accompanying fee as indicated above.
Send Patent to Knight Bros., McGill bldg., City.
KNIGHT BROS., *Attorney-*.

1847 2–191.

C. E. R.

Serial No. 200,649.

Address only "The Commissioner of Patents, Washington, D. C."

Department of the Interior,
United States Patent Office,
Washington, D. C., April 5, 1905.

Arthur E. Cattermole, Henry L. Sulman and Hugh F. Kirkpatrick-Picard, c/o Knight Bros., City.

SIR: You are informed that the final fee of twenty dollars has been received in your application for Improvement in Ore Concentration.

Very respectfully,
F. I. ALLEN,
Commissioner of Patents.

[Here follows printed copy of Patent 788,247.]

1848 1904.

Contents.

83. Mills.
Ore and Coal Washers.

Print, —— —, ——.
Application, — papers, O. K.
1. Rej., Apr. 29, 1904.
2. Amendment A, Aug. 9, 1904.
3. Rej., Oct. 4, 1904.
4. Amendt. B and Argt., Dec. 21, 1904.
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Title: Improvement in Ore Concentration.

1849 DEFENDANT'S EXHIBIT.

Certified Copy of File-wrapper and Contents of Sulman, Kirkpatrick-Picard Patent No. 793,808.

United States of America,

Department of the Interior.

United States Patent Office.

To all to whom these presents shall come, Greeting:

This is to certify that the annexed is a true copy from the Records of this Office of the File Wrapper, Contents and Drawings, in the matter of the Letters Patent of Henry Livingstone Sulman, and Hugh

Fitzalis Kirkpatrick-Picard, Number 793,808, Granted July 4, 1905, for Improvement in Ore Concentration.

In testimony whereof I have hereunto set my hand and caused the seal of the Patent Office to be affi ed at the City of Washington, this 31st day of January, in the year of our Lord one thousand nine hundred and twelve and of the Independence of the United States of America the one hundred and thirty-sixth.

[SEAL.] F. A. TENNANT,
Assistant Commissioner of Patents

1850 2–437.

Number (Series of 1900).
175,871.

Div. 25.
(Exr.'s Book.) 16-105.

1903.

Patent No. 793,808.

I. 2.

Name: Henry Livingstone Sulman and Hugh Fitzalis Kirkpatrick-Picard, of London.
County of ——, of England.
Invention: Ore Concentration.

Parts of Application filed.	Original.	Renewed.
Petition,	Oct. 5, 1903,	—— —, 190-.
Affidavit,	" " 1903,	—— —, 190-.
Specification, 3 shts.	" " 1903,	—— —, 190-.
Drawing,	Dec. 15. 1903,	—— —, 190-.
Sub " 1 sht.	Mar. 15, 1905,	—— —, 190-.
Model or Specimen Not reqd.,	—— —, 190–,	—— —, 190-.
1 First Fee, Cash, $15.00,	—— —, 1903,	—— —, 190-.
" " Cert.,	—— —, 190–,	—— —, 190-.
Appl. filed complete	Oct 5, 1903,	—— —, 190-.
Examined, Lewis B. Wynne	Mch. 27th, 1905,	—— —, 190-.
Countersigned, J. W. Babson, For Commissioner.		—— —, 190-. For Commissioner.

Notice of Allowance, March 29, 1905, —— —, 190-.
Final Fee, Cash $20, June 12, 1905, —— —, 190-.
" " Cert., " —, 190-, —— —, 190-.
2. Patented July 4, 1905.
Associate Attorney, —— ——. Attorney-, Knight Bros.,
McGill Bldg., City.
Name, ——. Serial Number, ——.
3. Patent No. ——. Date of Patent, ——.

[On left margin:] Division of App. No. —, filed —— —, 190-.

1851 Serial No. 175,871; Paper No. 1½.

$15 Received Oct. 5, 1903. H. Chief Clerk, U. S. Patent Office.

Application.

Filed—— —, 1903.

Joint Petition.

To the Commissioner of Patents:

Your Petitioners Henry Livingstone Sulman and Hugh Fitzalis Kirkpatrick-Picard, Subjects of the King of England and residents of London, England, whose Post Office address is 44 London Wall, City of London, England, *and* pray that Letters Patent may be granted to them, as joint inventors, for the Improvements in or relating to ore concentration, set forth in the annexed Specification, and they hereby appoint Knight Bros., Washington, D. C., composed of Hervey S. and Harry A. Knight their Attorney- with full power of substitution and revocation, to prosecute this application, to make alterations and amendments therein, to receive the Patent, and to transact all business in the Patent Office connected therewith.

Signed at London England this 25th day of September 1903.

HENRY LIVINGSTONE SULMAN.
HUGH FITZALIS KIRKPATRICK-PICARD.

1852 U. S.:

To all whom it may concern:

Be it known that We, Henry Livingstone Sulman and Hugh Fitzalis Kirkpatrick-Picard, subjects of the King of England residing at London England have invented certain new and useful "Improvements in or Relating to Ore Concentration" of which the following is a specification:

The present invention relates to the concentration of ores by separation of the metalliferous constituents and graphite, carbon, sulphur and the like from the gangue by means of oils, grease, tar,

or any similar substance which has a preferential affinity for metalliferous matter over gangue.

According to this invention we utilize the power which is possessed by films or bubbles of air or other gas of attaching themselves to solid particles moistened by oil or the like.

According to one method of carrying out our invention suitably crushed ore is suspended in water; to this suspension a proportion of oil, grease or tar (hereinafter referred to as "oil") is added and duly mixed with the mass by any suitable means in quantity insufficient to raise the oiled mineral, by virtue of the flotation power of the oil alone.

A suitable gas is now generated in or introduced into the mixture, such as air, carbonic acid gas, sulphuretted hydrogen or the like. For example, bi-carbonates or carbonates, either soluble or insoluble in water (preferably the latter), or easily decomposible sul-
1853 phides and the like may be used with acid solution. In such cases, if desired, the addition of acid may be made to the mixture after the addition of the gas-producing reagent. In the case of solutions containing free alkali, the addition of acid sufficient to neutralize this must be made before the gas is produced. If desirable gaseous bubbles may be produced by electrolytic methods, or by means of various other known reactions.

According to another method of carrying out this invention, the "oil" is not added alone but the pulp is submitted to the action of a current of air or other gas-bubbles, the air or other gas being first suitably charged either with the vapour of a volatile oil, such as petroleum of low boiling point, or with the spray of any other suitable volatile or non-volatile or fixed oil or the like.

The oil may be sprayed or reduced to a state of such fine division that minute globules of the same can remain temporarily suspended in an air or other gas current by the use of any suitable spraying or atomizing device, and the air current introduced into the ore pulp, preferably at the bottom, by means of a pipe or pipes provided with suitable perforations or by other suitable contrivance. The minute oil globules or the condensed vapours of volatile oils attach themselves to the metalliferous particles in preference to the gangue.

The oiled metalliferous particles resulting from either of the processes above described have the power of attaching to themselves with a greater comparative strength than the gangue particles, the
1854 films or bubbles of gas which exist in the mass, and are thus raised to the surface of the liquor by gaseous flotation; they can then be removed by skimming, or other suitable means. The gangue particles unwetted by oil or grease are not floated up with the oiled mineral particles, and thus in the main remain at the bottom of the vessel containing the mixture. The oil can then be removed from the oiled mineral by any suitable known means.

In the case in which oil spray is used, the temperature of the mass of pulp may be varied to secure the best results with spray of oils of varying viscosity. Instead of suspending the oil spray in an air supply system, suitably devised atomising jets operated by air, or a jet of steam and air may be introduced directly into the pulp.

The gas used may be other than air such as carbonic acid, steam or mixtures of these.

We have also found that a particle of metalliferous mineral if coated with a minute film of oil, grease or the like then exposed to air will not readily sink in the water. It is therefore unnecessary in some instances to employ gaseous bubbles to effect flotation. For example according to an alternative method for effecting the separation of metalliferous matter from gangue, the metalliferous ore pulp is intimately mixed in any suitable manner with a small proportion of "oil" and then sprayed in as finely divided a state as necessary through air by means of jets, revolving discs or otherwise; and the sprayed product is then allowed to fall upon the surface of
1855 water. The gangue particles wetted only with water at once sink, while the metalliferous particles coated with a thin film of oil and after exposure to air float on the surface of the water and may be removed by skimming or other suitable means. Before bringing the pulp into the necessary contact with air it will be obvious that the bulk of the water may first be removed by subsidence or other suitable means.

Insert B, Dec. 15/03.

This process has been described as applied to ore concentration by oil, but it is to be understood that it is equally applicable to concentration by the use of any other substance which has an affinity for metalliferous matter.

U. S.

Sub. B, Dec. 15/03.

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1. The hereindescribed process of concentrating ores which consists in bringing the pulp into intimate contact with "oil" and with a gas and thereafter separating the metalliferous constituents from the gangue. (in water ^)

Oct. 29/03.

2. The hereindescribed process of concentrating ores which consists in bringing the pulp into intimate contact with a spray of "oil" and with a gas and thereafter separating the metalliferous constituents from the gangue. (in water ^)

Oct. 29/03.

3. The hereindescribed process of concentrating ores which consists in bringing the pulp into intimate contact with "oil," disseminating the mixture through air and thereafter separating the metalliferous constituents from the gangue in water.

[Matter enclosed between rules erased in copy.]

Insert Λ, Oct. 29/03.

In testimony whereof we have signed our names to this
1856 Specification in the presence of two subscribing witnesses.

HENRY LIVINGSTONE SULMAN.
HUGH FITZALIS KIRKPATRICK-PICARD.

2 Witnesses:
CLAUDE C. R. McKENZIE.
WALTER J. SKERTEN.

Oath.

LONDON,
England, ss:

Henry Livingstone Sulman, and Hugh Fitzalis Kirkpatrick-Picard, the above named petitioners, being sworn, depose and say they are subjects of the King of England, and residents of London, in England, that they verily believe themselves to be the original, first and joint inventors of the "Improvements in or Relating to Ore Concentration" described and claimed in the annexed specification; that they do not know and do not believe that the same was ever known or used before their invention or discovery thereof, or more than two years prior to this application, or in public use or on sale in the United States for more than two years prior to this application; that said invention has not been patented to them or to others with their knowledge or consent in this or any foreign country for more than two years prior to this application, or on an application for a patent filed in any country foreign to the United States by them or their legal representatives or assigns more than twelve months prior to their application; and that no application
1857 for patent on said improvement has been filed by them or their representatives or assigns in any country foreign to the United States, except as follows—in Great Britain under Nos. 16285, dated 23rd July 1903, and 20419 dated 22nd September 1903.

Inventors' Signatures in full:

HENRY LIVINGSTONE SULMAN.
HUGH FITZALIS KIRKPATRICK-PICARD.

Sworn to and subscribed before me this 25th day of September 1903, by both said Deponents.

[NOTARIAL SEAL.] G. F. WARREN,
Notary Public.

M.

[Revenue Stamp.]

Consulate-General of the United States of America for Great Britain & Ireland at London.

I, Henry Clay Evans Consul-General of the United States of America at London, England do hereby make known and certify to all whom it may concern that George Frederick Warren who hath

signed the annexed Certificate, is a Notary Public, duly admitted and sworn and practising in the city of London, aforesaid, and that to all acts by him so done full faith and credit are and ought to be given in Judicature and thereout.

In Testimony Whereof, I have hereunto set my hand and affixed my Seal of Office at London aforesaid, this 26" day of September— in the year of our Lord One Thousand Nine Hundred and Three.

[CONSULAR SEAL.] H. CLAY EVANS,
Consul-General.

1858 2–260.

M. E. C.

Div. —, Room 315.

Address only "The Commissioner of Patents, Washington, D. C."

Paper No. 1.

All communications respecting this application should give the serial number, date of filing, and title of invention.

Department of the Interior,
United States Patent Office,
Washington, D. C., Oct. 20, 1903.
Mailed " " "

H. L. Sulman & H. F. Kirkpatrick-Picard, Care Knight Bros., City:

Please find below a communication from the Examiner in charge of your application, #175,871, filed Oct. 5, 1903, for Ore Concentration.

F. I. ALLEN,
Commissioner of Patents.

Applicants are required to supply a drawing illustrating means for carrying out the process described in this application.

The claims are rejected in view of British patent to Lake, 12778, of 1902, Washers; and e. g., 668,742, Redding, Feb. 26, 1901, Washers, A.

T. F. MITCHELL,
Act'g Examiner, Division XXV.

1859 Serial No. 175,871, Paper No. 2.

Application Room,
Oct. 29, 1903,
U. S. Patent Office.

Patent Office.
Oct. 31, 1903,
Division XXV.

Amendment.

Inventor: Sulman & Kirkpatrick-Picard. Invention: Ore Concentration. Filed October 5, 1903. Serial No. 175,871.

Hon. Commissioner of Patents.

SIR: The above-named application is hereby amended as follows:

Claims 1 and 2, line 4, after "separating" insert: *in water.*

Add the following claims:

Canceled Dec. 15/03.

A. 4. A process for concentrating ores, which consists in suspending the crushed ore in water, blowing into the same a gas containing finely divided oil, and removing the floating metalliferous portion.

5. A process for concentrating ores consisting in suspending the crushed ore in water, discharging into the mixture a gas saturated with a volatilized oil, and removing the floating metallic portion.

6. A process for concentrating ores, which consists in blowing a hydrocarbon vapor into a mixture of crushed ore and water, and removing the floating particles.

1860 7. A process for concentrating ores, which consists in treating the crushed ore with a hydrocarbon spray, separating in water the metallic portion from the gangue, and removing said metallic portion.

8. A process for concentrating ores which consists in mixing the crushed ore with a hydrocarbon, spraying the mixture into water, and removing the floating particles.

[Matter enclosed between rules erased in copy.]

Remarks.

Claims 1 and 2 have been amended to make clear the fact that the crushed ore is treated with the oil previously to being suspended in water. None of the references shows this feature. By treating the dry ore with oil the metallic particles are enabled to take up with the oil to a much greater extent than could occur in water consequently better results are obtained. Claims 3, 7 and 8 also make the same distinction.

Claims 4, 5 and 6 are drawn to include blowing a gas into the

mixture of water and crushed ore. The only equivalent of this is found in the British patent cited, and as this reference calls for an acid solution and an effervescent salt to obtain the same result, the metal would be acted upon by the acid as long as it was in the liquid. The objections to this are obvious.

Claim 8 contains the additional feature of spraying the oiled, crushed ore upon water. This is broadly new we believe in so far as the reference discloses.

In the Redding reference no mention is made of using artificial means, such as oil, for floating the metallic particles. We
1861 submit that this reference has no bearing on the claims.

In consideration of the amendment and remarks we respectfully urge a favorable action upon the claims, with the understanding that a drawing will be filed at an early date. Our client is abroad and there will necessarily be some lapse of time before we can receive a drawing from him in this case.

Respectfully submitted, KNIGHT BROS.

Washington, D. C., October 28, 1903.

W.

2-260.

M. E. C.

Div. —, Room 315.

Address only "The Commissioner of Patents, Washington, D. C."

Paper No. 3.

All communications respecting this application should give the serial number, date of filing, and title of invention.

Department of the Interior,

United States Patent Office,

Washington, D. C., November 12, 1903.
Mailed " " "

Henry Livingstone Sulman and Hugh Fitzalis Kirkpatrick-Picard, Care Knight Bros., City:

Please find below a communication from the Examiner
1862 in charge of your application, #175,871, filed Oct. 5, 1903, for Ore Concentration.

F. I. ALLEN,
Commissioner of Patents.

The amendment filed October 29, 1903, has been entered by inadvertence. Action on the merits must be refused until applicants restrict the claims to a simple species.

The spraying of the mixed pulp oil through air (claim 3); the *spraying* of pulp with oil before separation (claim 2); the *spraying* of crushed ore suspended in water (claim 4); the use of a gas carrying volatilized oil (claim 5); are examples of different species, as are the methods of the 6th to 8th claims.

LEWIS B. WYNNE,
Examiner, Division XXV.

T. F. M.

1863 Serial No. 175,871, Paper No. 4.

Application Room,
Dec. 15, 1903,
U. S. Patent Office.

Patent Office,
Dec. 16, 1903,
Division XXV.

Room No. 315.

Amendment.

Inventors: Henry L. Sulman & H. F. Kirkpatrick-Picard. Invention: Ore Concentration. Filed October 5, 1903. Serial No. 175,871.

Hon. Commissioner of Patents.

SIR: The above-named application is hereby amended as follows:

In accordance with the Examiner's requirements a drawing is filed herewith illustrating means for carrying out the process described in this application.

Specification: Page 4, line 14, after "means" insert:

B. In the accompanying drawings:

Figure 1 is a diagram in longitudinal section of an apparatus suitable for carrying out this process.

Figure 2 is a diagram in perspective, partly in section of another form of suitable apparatus, and

Figure 3 is a diagram in perspective, partly in section of an alternative form of apparatus.

1864 Referring to Figure 1, A is a tank for pulp which delivers through a pipe A′ to a concentrating tank B the bottom of which slopes downward from the inlet. The tank B is provided at the bottom with a coiled pipe B′ suitably perforated, supported in bearings B^2 and arranged to be rotated by means of a spur wheel B^3 or the like. Air is forced into this pipe B′ through a pipe C and oil is simultaneously introduced into the pipe C from a carburettor or the like C′. At the end of the tank B furthest from the pulp inlet, a launder B^4 is placed to receive the discharge of floating material and an outlet tap B^5 is provided at the lowest point of the tank.

Referring to Figure 2, D is a tank in which pulp and oil are mixed and the mixture passes through an outlet tap D′ to an ejector E through which air under pressure is passed by

the pipe E'. The spray of pulp, oil and air falls into a tank F filled with water and consisting of a series of communicating pointed boxes which increase in depth from the inlet end. A launder F' is provided at the outlet end of the tank and outlet taps F^2 are placed at the lowest points of the boxes.

Referring to Figure 3, G is a tank in which pulp and oil are mixed, H is a circular disc attached to a vertical spindle H' supported in bearings H^2 and arranged to be rotated through a driving pulley H^3 or the like. Surrounding the spindle is a cylindrical collar J connected with the tank G by a pipe J' so that the pulp and oil are fed through the collar to the rotating disc. Surrounding the disc is a series of annular pointed troughs K communicating with one another and increasing in depth towards the outside and filled with water. A launder K' is provided at the periphery of the outside trough to receive the discharged floating material and outlet taps K^2 are placed at the lowest points of the troughs.

1865

Cancel the claims and substitute the following:

B[1]. 1. The herein described process of concentrating ores which consist in bringing the pulp into intimate contact with "oil" in the form of spray and with a gas and thereafter separating the metalliferous constituents from the gangue.

2. The herein described process of concentrating ores which consists in bringing the pulp into intimate contact with "oil" disseminating the mixture through air and thereafter separating the metalliferous constituents from the gangue water.

Remarks.

The specifications cited have been considered and the Examiner's attention is directed to the following points:

Lake (Froment) British Patent No. 12778/02. It is clear that this specification discloses the principle of the liberation of gas bubbles in a mixture of ore pulp and oil, in order to raise the oiled mineral to the surface; and Froment considers that the action takes place most effectively when the gas is in a nascent state as when the gas is directly generated in the pulp. Froment, however, has not recognized the advantages which result from using oil in the form of spray.

1866

It is very important to notice that if the oil be atomized in an air, or other gas current every minute particle of oil is brought into intimate contact with the gas and with the metalliferous mineral, with the result that the particles of oiled mineral adhere to films or bubbles of gas with great rapidity. Further, the particles of metalliferous mineral being in some cases very small, it is essential to have the oil and adhering gas in a correspondingly fine state of division and this is obtained in the Sulman and Picard process of atomizing the oil.

The particular method invented by Messrs. Sulman & Picard for causing the finely divided oil to be exposed to air is a specially rapid and convenient method of effecting the intimate contact of the minute particles of oil and mineral with air, and the resulting adhesion of these.

Redding U. S. No. 668,742. This specification describes an apparatus for separating graphite from ore, depending upon the fact that finely divided graphite will float on water. The ground ore is dropped on to a moving surface of water and is widely distributed and blown over the surface of the water. The heavy material sinks while the particles of graphite are floated off.

This is not an oil process: it is not suggested that the air
1867 attaches itself in anyway to the graphite or that the flotation of the graphite is effected by the action of the air. On the contrary it is clearly stated on page 1 lines 13 to 15 that the graphite floats because it is in the form of scales or laminæ which repel water.

So far as the Sulman & Picard process is concerned this citation appears to have no particular bearing, as owing to the absence of oil, it is impossible that Redding can have used a current of air for the purpose of producing intimate contact between the air and a spray of atomized oil to cause the latter to adhere to metalliferous mineral and float.

A favorable action is respectfully solicited.

Respectfully submitted,

KNIGHT BROS., *Attorneys.*

Washington, D. C., December 12, 1903.

W.

1868 2–260.

M. E. C.

Div. —, Room 315.

Address only "The Commissioner of Patents, Washington, D. C."

Paper No. 5.

All communications respecting this application should give the serial number, date of filing, and title of invention.

Department of the Interior,

United States Patent Office,

Washington, D. C., Dec. 18, 1903.
Mailed " " "

Sulman & Kirkpatrick-Picard, Care Knight Bros., City:

Please find below a communication from the Examiner in charge of your application, #175,871, filed Oct. 5, 1903, for Ore Concentration.

F. I. ALLEN,
Commissioner of Patents.

Case as amended Dec. 15, 1903, further considered.

The drawing filed has been criticized as follows: "Informal; space for heading required; see sheet 3. Admit for examination only." The claims bear the relation of two different species rather than that of genus and species. Restriction to a single species is required in advance of action upon the merits.

T. F. MITCHELL,
Act'g Examiner, Div. XXVI.

T. F. MITCHELL.

1869 Serial No. 175,871, Paper No. 6.

Application Room,
Mar. 18, 1904,
U. S. Patent Office.

Patent Office,
Mar. 19, 1904,
Division XXV.

Room No. 315.

Inventors: Sulman & Picard. Invention: Ore Concentration.
Filed October 5, 1903. Serial No. 175,871.

Hon. Commissioner of Patents.

SIR: The Examiner's remarks have been considered and the inventors cannot appreciate the objection that "the claims bear the relation of two different species rather than of genus and species."

The essential feature of the applicants' invention is that in the separation of minerals by oil, the oil is used in the form of a spray and Messrs. Sulman & Picard have discovered that the affinity of the oil for the mineral and particles of air is more active and rapid if the oil be finely divided.

The first claim at present on file is as follows:

The herein described process of concentrating ores which consists in bringing the pulp into intimate contact with oil in the form of spray and with a gas and thereafter separating the metalliferous constituents from the gangue.

It is submitted that this claim is directed to the genus of the process and while several methods have been described and
1870 illustrated by which the oil may be sprayed, each of these methods comes within the scope of this first claim.

The second claim is specially directed to the preferred form of the process, as illustrated in Figure 3, consisting in bringing the pulp into intimate contact with the oil, disseminating the mixture through air and thereafter separating the metalliferous constituents from the gangue in water, but the oil at the moment when it becomes attached to the particles of air is clearly in the form of a spray and it is submitted that the process covered in claim 2 is therefore a species of that covered in claim 1 and a re-examination of the claims is therefore respectfully requested.

Respectfully submitted,

KNIGHT BROS., *Attorneys.*

Washington, D. C., March 18, 1904.

H.

1871

2–260.

M. E. C.

Div. 25, Room 315.

Address only "The Commissioner of Patents, Washington, D. C."

Paper No. 7.

All communications respecting this application should give the serial number, date of filing, and title of invention.

Department of Interior,

United States Patent Office,

Washington, D. C., April 5, 1904.
Mailed " " "

Henry Livingstone Sulman & Hugh Fitzalis Kirkpatrick-Picard, Care Knight Bros., City:

Please find below a communication from the Examiner in charge of your application #175,871, filed Oct. 5, 1903, for Ore Concentrator.

F. I. ALLEN,
Commissioner of Patents.

Case as argued March 18, 1904, further considered.

In view of the explanation supplied, the requirement of division is withdrawn.

The claims may possibly be allowed.

The case now awaits the relieving of the drawing of formal objections.

LEWIS B. WYNNE,
Examiner, Division XXV.

T. F. MITCHELL.

1872 Serial No. 175,871, Paper No. 8.

Application Room,
Mar. 15, 1905,
U. S. Patent Office.

Patent Office,
Mar. 16, 1905,
Division XXV.

Room No. 315.

Amendment.

Inventor: Henry L. Sulman & H. F. K. Picard. Invention: Ore Concentration. Filed October 5, 1903. Serial No. 175,871.

Hon. Commissioner of Patents.

SIR: The above-named application is hereby amended as follows:

Cancel Figure 3 of the drawing now in the case and substitute the sheet of drawing attached hereto.

The case is now in condition for allowance and an early action is solicited.

Respectfully submitted,

KNIGHT BROS., *Attorneys.*

Washington, D. C., March 14, 1905.

H.

1873 2–181.

A. R.

Issue Division.

Serial No. 175,871.

All communications should be addressed to "The Commissioner of Patents, Washington, D. C."

Department of the Interior,

U. S. Patent Office,

Washington, D. C., March 29, 1905, *190–*.

Henry L. Sulman and Hugh F. Kirkpatrick-Picard, c/o Knight Bros., City.

SIR: Your application for a patent for an Improvement in Ore Concentration. Filed Oct. 5, 1903, *1* . . . , has been examined and allowed.

The final fee, Twenty Dollars, must be paid, and the Letters Patent bear date as of a day not later than six months from the time of this present notice of allowance.

If the final fee is not paid within that period the patent will be withheld, and your only relief will be by a renewal of the application, with additional fees, under the provisions of Section 4897, Revised Statutes. The Office aims to deliver patents upon the day of their date, and on which their term begins to run; but to do this properly applicants will be expected to pay their final fees at least twenty days prior to the conclusion of the six months allowed them by law. The printing, photo-lithographing, and engrossing of the several patent parts, preparatory to final signing and sealing, will consume the intervening time, and such work will not be done until after payment of the necessary fees.

1874

When you send the final fee you will also send, distinctly and plainly written, the name of the inventor and title of invention as above given, date of allowance (which is the date of this circular), date of filing, and, if assigned, the names of the assignees.

If you desire to have the patent issue to assignees, an assignment containing a request to that effect, together with the fee for recording the same, must be filed in this Office on or before the date of payment of final fee.

After issue of the patent uncertified copies of the drawings and specifications may be purchased at the price of 5 cents each. The money should accompany the order. Postage stamps will not be received.

Respectfully,

F. I. ALLEN,
Commissioner of Patents.

After allowance, and prior to payment of the final fee, applicants should carefully scrutinize the description to see that their statements and language are correct, as mistakes not incurred through the fault of the office, and not affording legal grounds for reissues, will not be corrected after the delivery of the letters patent to the patentee or his agent.

In remitting the final fee give the Serial Number at the head of this notice.

If payment is made by check or draft, the credit allowed is subject to the collection of the same.

1875 2–327.

√$20.00 Received Jun- 12, 1905. H. Chief Clerk, U. S. Patent Office.

Memorandum of Fee Paid at United States Patent Office.

(Be careful to give correct Serial No.)

Serial No. 175,871. —— —, 190–.
Inventor-: Henry L. Sulman & H. F. Kirkpatrick Picard.
Patent to be issued to —— ——.
Name of invention, as allowed: Ore Concentration.
Date of Payment: Jun- 12, '05.
Fee: $20.
Date of Filing: Oct. 5, 1903.
Date of Circular of Allowance: March 29, '05.
The Commissioner of Patents will please apply the accompanying fee as indicated above.
Send Patent to Knight Bros. McGill Bldg., City.
KNIGHT BROS., *Attorneys.*

1876 2–191.

C. E. R.

Serial No. 175,871.

Address only "The Commissioner of Patents, Washington, D. C."

Department of the Interior,
United States Patent Office,
Washington, D. C., June 12, 1905.

H. L. Sulman & H. F. Kirkpatrick-Picard, c/o Knight Bros., City.

SIR: You are informed that the final fee of twenty dollars has been received in your application for Improvement in Ore Concentration.

Very respectfully,
F. I. ALLEN,
Commissioner of Patents.

[Here follows printed copy of Patent 793,808.]

1877

1903.

Contents.

83. Mills.
Ore and Coal Washers.

Print, —— —, ——.
Application, — papers, O. K.
1. Rej., Oct. 20, 1903.
2. Amendment A, Oct. 29, 1903.
3. Rej., Nov. 12, 1903.
4. Amendment B, Dec. 15, 1903.
5. Letter, Dec. 18, 1903.
6. Argument, Mar. 18, 1904.
7. Letter, Apr. 5, 1904.
8. Amendt. to Drg., Mar. 15, 1905.
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Title: Improvement in Ore Concentration.

No. 793,808. PATENTED JULY 4, 1905.

H. L. SULMAN & H. F. KIRKPATRICK-PICARD.

ORE CONCENTRATION.

APPLICATION FILED OCT. 5, 1903.

3 SHEETS-SHEET 1

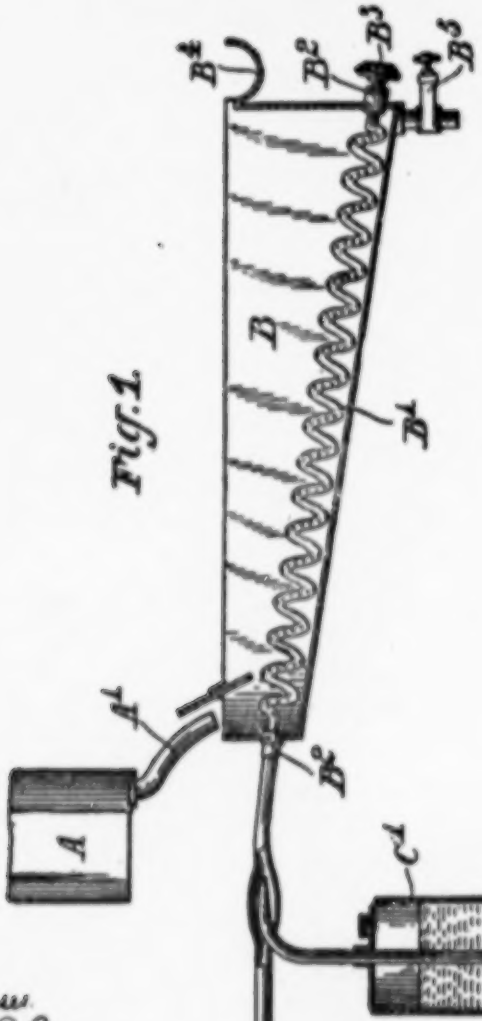

Fig. 1.

Witnesses:
Harold Hoe
J. M. Hopkins

Inventors
Henry L. Sulman
and Hyde F. Kirkpatrick-Picard
By Knight Bros.
Attys

No. 793,808. PATENTED JULY 4, 1905

H. L. SULMAN & H. F. KIRKPATRICK-PICARD.

ORE CONCENTRATION.

APPLICATION FILED OCT 5, 1903

3 SHEETS-SHEET 2

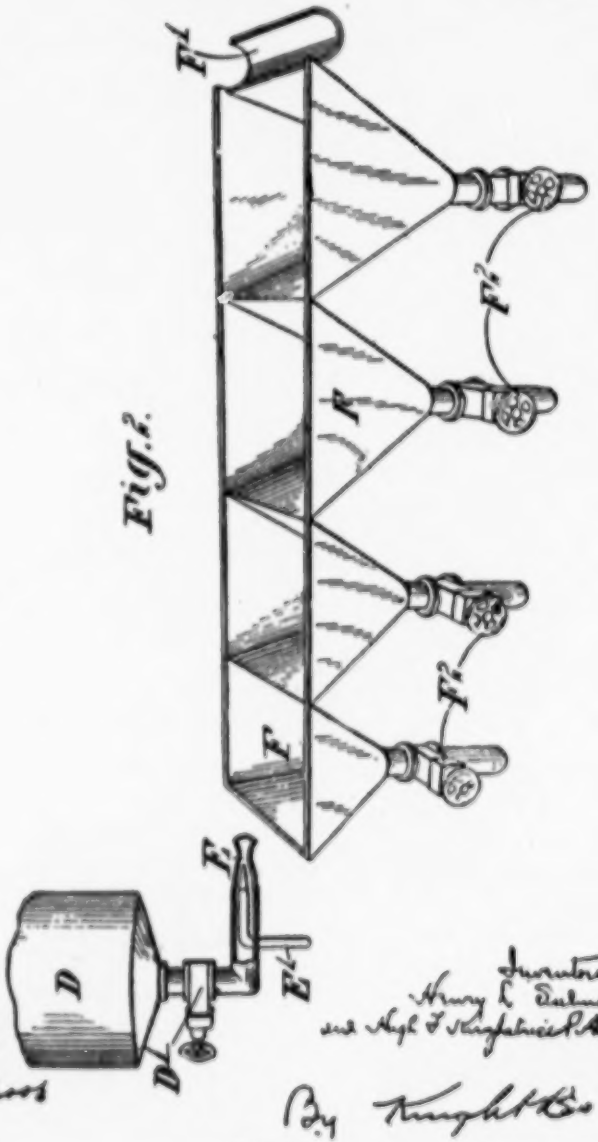

Fig. 2.

Witnesses
Arthur Knight
L. M. Hawkins

Inventors
Henry L. Sulman
and Hyl F. Kirkpatrick-Picard
By Knight Bros

No. 793,808. PATENTED JULY 4, 1905.

H. L. SULMAN & H. F. KIRKPATRICK-PICARD.

ORE CONCENTRATION.

APPLICATION FILED OCT. 6, 1903.

3 SHEETS—SHEET 3

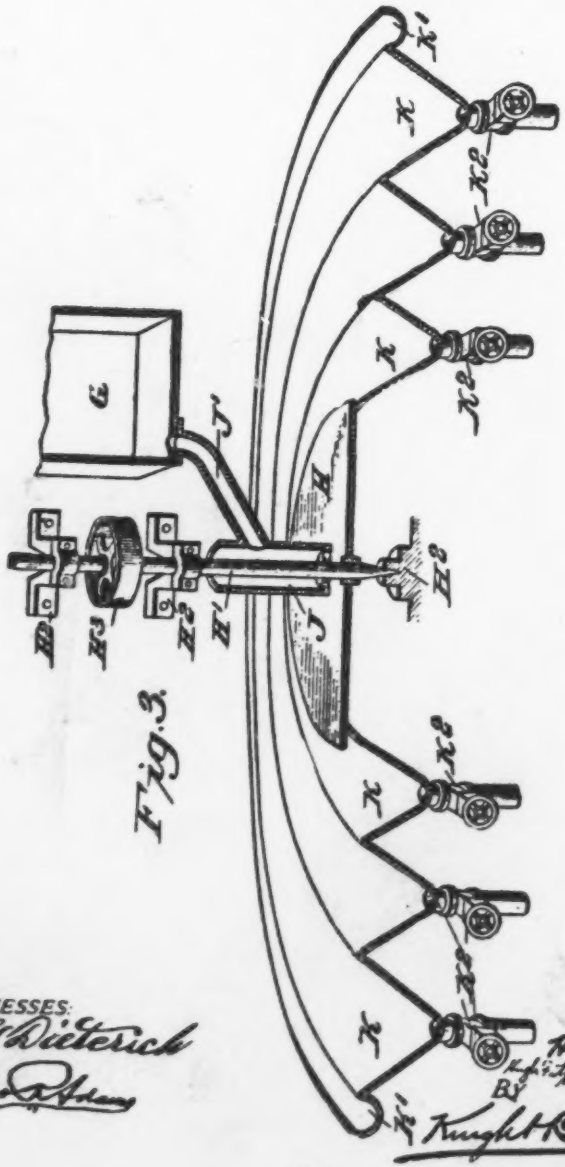

Fig. 3.

WITNESSES:

H. C. Dieterich

Jno. A. Adams

INVENTOR

Henry L. Sulman

Herbert Kirkpatrick-Picard

By Knight Bros.

Attorneys